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https://doi.org/10.5109/23839

出版情報：九州大学大学院農学研究院紀要. 31 (1/2), pp.101-143, 1987-02. Kyushu University
バージョン：
権利関係：

J. Fac. Agr., Kyushu Univ., 31 (1•2),101-143(1987)

Agricultural Development through Irrigation in Thailand

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(Received July 26, 1986)

The basic hypothesis in this paper is that poverty in developing countries can be partly solved by an adequate supply of water for agricultural use through irrigation, The introduction of irrigation will improve and stabilize yearly rice yield, and enable the introduction of new kinds of crops, These effects of irrigation will increase the agricultural income, and will consequently enable the purchase of modern inputs, provide an opportunity for the local children to receive higher eduction, which in turn will result in further increase in productivity. To prove this hypothesis we selected the Nong Wai Pioneer Agriculture Project in North-East Thailand for our case study, as there has been very little research done on this part of North-East Thailand, and is the region which is most striken by poverty. A questionnaire was held involving 75 farm households in villages, in and around the project. The 75 households were divided evenly in three groups depending on the method of irrigation they employed, intensive irrigation, extensive irrigation and rain-fed. From the data collected we verified the agricultural development brought about by irrigation. We also found many obstacles which retarded the agricultural development through irrigation.

INTRODUCTION

In this paper, as shown in Fig. 1, the assumption is that poverty in developing countries arises from :

(1) low productivity in rice yields caused by low, erratic rainfall ;
(2) lack of employment opportunities in the underdeveloped non-agricultural sector of the economy.

It is also assumed that the above factors which lead to poverty can be partly solved by an adequate supply of water for agricultural use through irrigation. The basic understanding is that the introduction of irrigation will (1) improve and stabilize yearly rice yield per rai (1 rai=0.16 ha) ; (2) enable the introduction of new kinds of crops, which will increase the opportunities of employment in the agricultural sector, brining an increase in the overall agricultural income. This increase in income in the agricultural sector will enable (3) the purchase of new varieties of crops, fertilizers, agricultural chemicals and implements. Furthermore, it will allow (4) opportunities for the indigenous population to receive higher education, resulting in further increase in productivity. In this paper, we hope to prove the above hypothesis by analyzing the changes in agricultural management brought about by irrigation development.

We have selected the Nong Wai Pioneer Agriculture Project in North-East Thailand for our case study, the reason being that at the time of study the Nong Wai Agriculture Project was still in its initial stages. As the development of the irrigation system was still in its infant stages, the villages in and around the Nong Wai Pioneer

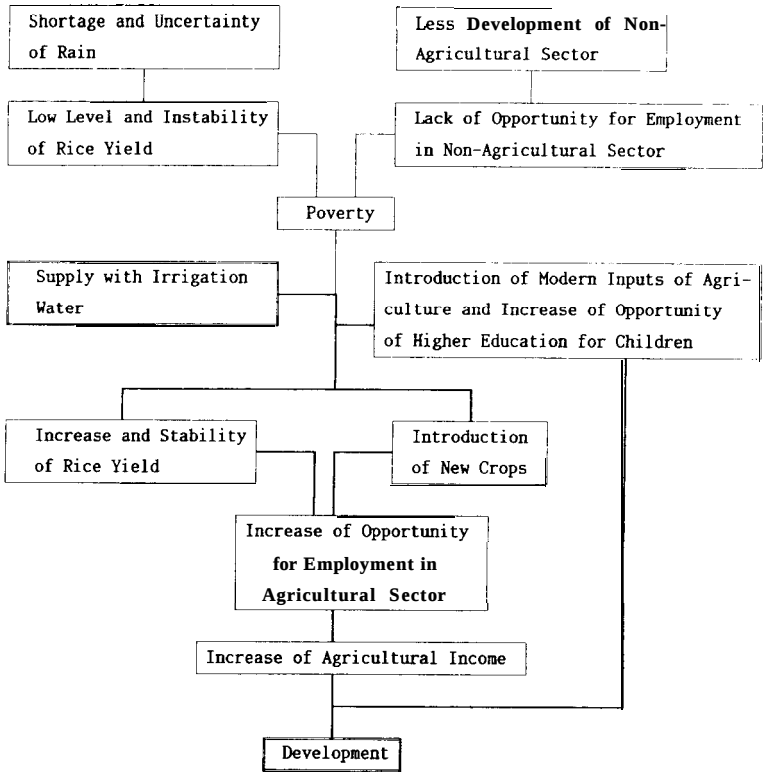

Fig. 1. Agricultural development through irrigation (hypothesis of this paper).

Agriculture Project still suffered from poverty. In order for irrigation development to succeed in relieving poverty, the construction of dams and main canals, and also land consolidation of individual farms is necessary (Tsuchiya, 1981). Accordingly, we have chosen the farm households in and around the Nong Wai Pioneer Agriculture Project for our survey, the reason being that households in this area practice either intensive irrigation where individual drainage is possible, or the older extensive irrigation method of plot-to-plot irrigation. In both circumstances land consolidation has taken place. Consequently, this gives us the opportunity to see what effects irrigation development has on the agricultural household in the area.

Much of the excellent research done on the subject of irrigation and agricultural development in Thailand uses Chao Phraya Delta as a case study (Isii, 1975 ; Takaya, 1982). There has been little research done on the subject of irrigation in North-East areas of Thailand, which is the most stricken by poverty. Since most of the paddy fields in North-East Thailand are dependent on rain to water their crops, in the years of drought, like the year of our study, the local farmers were unable to plant their annual rice crop. Consequently, many of them were economically forced to go to other areas for work. This insecurity in livelihood is why irrigation development in North-East Thailand is of the utmost importance.

MATERIALS AND METHODS

1. The geographical and social conditions of North-East Thailand

The geographical conditions of North-East Thailand (Hasegawa, 1983) are as follows :

(1) Mountains account for 35 % of the whole acreage.
(2) The climate is very unsuitable for rice cultivation due to the inconsistency in rainfall and re-occurring droughts.
(3) The recent, drastic decrease in forests due to indiscriminate clearing has caused frequent floods and droughts.
(4) The soil is poor, with the fertile alluvial soil accounting only for 5.7 % of the whole acreage.

The social conditions of North-East Thailand (Hasegawa, 1983) are :

(1) The population increase in this region is higher than other region.
(2) North-East Thailand accounts for 33 % of the total acreage of Thailand. However, 40 % of the total farm households in Thailand are found in North-East Region.
(3) The use and expansion of the farmland has reached its natural limit.
(4) The increase in farm households has led to the predominance of small-scale farming management.
(5) Irrigated land accounts for only 5.3 % of the total acreage of paddy fields in North-East Thailand. This is very low when one compares with the national average. The amount of irrigated land in the whole of Thailand accounts for 23 % of the total paddy fields acreage.
(6) The average rice yield per rai in this region is below the national average rice yield, a ratio of 10 : 7, and equals only 40 % of the average rice yield of North Thailand.
(7) Upland field cultivation has been introduced since 1960, but it has not spread further than along the main roads.
(8) The acreage of upland rice cultivation have been expanded.
(9) The rice produced in this region is mainly for domestic use.
(10) 94 % of the local farmers consider themselves to be owner operator farmers, and 54 % as full-time farmers.

The above stated geographical and social conditions of North-East Thailand show the obstacles which stand in the way of agricultural development in this region.

The villages in and around the Nong Wai Agriculture Project belong to Muang County in North-East Thailand. Muang County houses 24,679 farm households. The average acreage of one household is 16.4 rai.

2. The general conditions of villages in and around Nong Wai Pioneer Agriculture Project

The benefited acreage of the Nong Wai Pioneer Agriculture Project is approximately 68,000 rai (Kathpalia, 1983) and is inhabited by about 5,000 farm households. A questionnaire was held involving 75 of these farm households. The 75 households were divided evenly into three groups, depending on the method of irrigation they employed at the time of survey; intensive and extensive irrigation, and rain-fed. With the

Table **1.** Village names of the sample and number of sample farms.

Year of survey	Types of irrigation		R	Number of sample farms
	I	E		
1984	Dong Pong Village Don Yan Village	Noan Village Ton Villge	Noan Village Ton Village	30
1985	Song Pleuy Village	Bung Kae Village	Ton Village	45

Note : I.E.R denote Intensive irrigated area, Extensive irrigated area and Rain-fed area respectively. These symbols are used with the same meaning for the following tables.

assistance of the Royal Irrigation Department (R. I. D.), the following selections were made. As Table 1 shows, the areas of intensive irrigation chosen were Dong Pong, Don Yan and Song Pleuy Villages. The extensive irrigated area chosen were Noan, Ton and Bung Kae Villages. The Noan and Ton villages were also selected to represent villages where irrigation development had not taken place.

The farm households in the intensive irrigated area cultivate on irrigation-fed paddy fields where land consolidation has been fully completed, enabling the drainage of individual plots. The farm households in the extensive irrigated area mainly grow their crops on plot-to-plot irrigation paddy fields, although they do somethimes also cultivate on rain-fed paddy fields. The farm households in the rain-fed area cultivate only unirrigated paddy fields.

The general conditions of Song Pleuy Village in the intensive irrigated area are as follows. The village population at the time of our survey was 1,078 people, 195 households (an average of 5.5 members in one household). The total acreage of cultivated land in the village was 1,200 rai. Consequently, the average of the cultivated land per household was 6.2 rai. When this average is compared with other areas in Thailand, one can clearly see that the land available for cultivation per household is much smaller : i. e. in North-East Thailand, the average is 28 rai, and in Muang County, an average of 16.4 rai of cultivated land is available per household.

The yield of paddy field rice per rai was calculated to be 300 kg before the commencement of intensive irrigation. The productivity of land has risen to 400-500 kg per rai since the introduction of intensive irrigation. Since the commencement of irrigation, the cultivation of paddy fields during period of dry has been made feasible, resulting in the improvement in the land use rate.

The number of the farm households in this settlement has increased steadily. 20 years ago there were 70 households registered in the area, and the average acreage per household was 17 rai. However, being within easy access of Khon Kaen City which is only about 10 km away, the village population has increased constantly over the years. At the time of our survey, the average acreage per household had slightly diminished due to demographic pressures, and to the custom of equal inheritance among all family members. Furthermore, the completion of the irrigation system had indirectly brought about an increase in population ; subsequently, the diminution in the scale of cultivation.

The village possesses 45 2-wheel tractors and 40 buffaloes, which are used for

cultivation of the land. The cost of cultivation by hired 2-wheel tractor is 200 baht per rai. Both rice transplanting and harvesting are conducted by hand. The wage of a laborer for a day is 35 baht.

The farm households which possess less than 5 rai grow rice only for domestic consumption. Instead, they grow vegetables as their main cash crop.

In Thailand compulsory education ends at the sixth grade of the elementary school. The children who enter junior high school account for only 20 % of the total adolescent population. Recently, there has been gradual decrease in the number of elementary students. According to a local teacher, this is due to the considerable success of the family planning program.

More than half of the farm households in the intensive irrigated area possess a television set. Among them, 20 households possess a color television set. A black and white set costs 2,000-3,000 baht, while a color set cost 7,000-10,000 baht.

As was mentioned previously, the completion of the irrigation system in the surveyed areas has enabled (1) the improvement of paddy field rice cultivation, and (2) cultivation during period of dry. The completion of irrigation has also enabled a regular water supply for (1) vegetable growing, (2) the raising of duck and fish, (3) water for domestic use and (4) drinking water for cattle. The last two advantages have reduced the labor time lost by the local farmers who previously had to fetch water from distant wells.

The general conditions of Bung Kae Village in the extensive irrigated area are as follows. 18 years ago the village had a population of 600 and 135 farm households. After the initial introduction of irrigation the population increased to 721 and the number of households to 153 in the following 8 years. In the following 5 years the population increased even further ; 960 people or 172 households. At the time of survey, the total population was 1,200 with 206 households. The average number of the household members in one household was 5.8. The average cultivation acreage per household was 7 rai.

The establishment of irrigation system brough the following results to the village and village life.

(1) The damage by droughts was reduced.
(2) The yield of paddy field rice per rai increased.
(3) Cultivation of paddy field rice in dry periods became possible.
(4) The growing of the vegetables which required a regular supply of water, such as cucumber, cabbage, longbean, and lettuce, became feasible.
(5) The opportunities for employment in other farm households within the village settlement increased.
(6) The villagers were spared the labor of fetching water for domestic use and for watering their domestic animals.

All tenant farmers possessed some form of land. There were 9 tenant/owner households which comprised 4.4 % of the total households. The rest, 95.6 % of the households, were owner operator farmers. As only a few people left the village, and the practice of equal inheritance was prevalent, the management scale of each farm household had gradually been reduced. Consequently, advanced land utilization and the introduction of intensive farming procedure especially in vegetable growing, has become an urgent necessity.

Mr. A, who possesses 50 rai, has 9 children, 4 of whom are married. He has distributed 5 rai to the eldest daughter, 4 rai to the eldest son (his second child), and 3 rai to the second daughter (his third child). All three of these children are now engaged in farming of the land they received. However, Mr. A has not as yet given up land ownership. He is still engaged in farming, and at the time of survey was living with his third daughter (the fourth child), who was married. Mr. A says that he inherited 50 rai from his father. If he gives an equal portion of his land to each of his children, the land available to each child for farming will decrease drastically to about 11 rai. (This estimation is based on the assumption that a transfer of land from one family to another occurs with the acceptance of a wife/husband into the household. It is also assumed that the land transferred is equal to the land inheritance with which the spouse has married.)

It is generally estimated that a farm household consisting of parents and 4 children consumes 2,000 kg of paddy field rice (unhulled) annually. Taking the difference in weight between unhulled and milled rice to be a ratio of 10 : 6, the annual consumption of milled rice per family member is 200 kg annually. It follows that, in order to produce 2,000 kg of unhulled rice for home consumption, a paddy field of 5 rai which produces an annual rice yield of 400 kg per rai is necessary. Consequently, at least 5 rai is necessary for the production of unhulled rice for home consumption.

3. **Method of research**

As mentioned earlier, the selection for our case study was made with the assistance of the R. I. D.. The selection of the 75 farm households for the survey were made with the assistance of the R. I. D. "Zone Man." A questionnaire was held with the assistance of the staff and students of the department of agricultural economics of Kasetsart and Khon Kaen Universities, involving 75 households. A questionnaire in both Thai and English was used. There were two year's surveys taken. The questionnaires were distributed and collected between August 7th and 11th of 1984, and October 24th and November 1st 1985. The questionnaires were concerned with the periods between April 1st 1983 to March 31st 1984, and April 1st 1984 to March 31st 1985. At the same time, a questionnaire survey was taken at the R. I. D., Kasetsart University, Thammasat University, the Ministry of Agriculture and Co-operatives, the Bank for Agriculture and Agricultural Coo-peratives, Agricultural Experiment Station, Agricultural Extension Office, primarily over the system of irrigation, agricultural finance in Thailand and the activities of agricultural cooperatives.

Once collected, the questionnaires were analyzed with a large-sized electronic computer. The results of the analysis will be dealt with in the following chapters.

RESULTS

1. **The composition of the farm households and agricultural labor force**

Table 2 shows the result of the survey concerning the composition of the village households and the agricultural labor force. The date denotes the date on which the survey was taken. In general, the husband was 4 to 5 years older than the wife. Most wives give birth to their first child between the ages of 22 or 23 ; the second after about a 3 year duration. The average number of children per family was 3 to 4. The total

Table 2. Composition of farm household members.

		1984			1985			Two years average		
		I	E	R	I	E	R	I	E	R
Age	Head	40.8	43.3	41.1	49.2	44.7	49.1	45.8	44.1	45.9
	Wife	35.7	39.5	38.2	41.5	41.4	42.6	39.2	40.6	40.8
	First child	15.0	17.1	15.2	19.7	17.4	19.9	17.8	17.3	18.0
	Second child	11.8	13.3	12.4	16.3	14.4	16.8	14.5	14.0	15.0
Number	Children	3.0	3.7	2.7	3.5	3.7	3.2	3.3	3.7	3.0
	Household members	5.3	6.5	5.9	6.2	6.0	5.7	5.8	6.2	5.8
	Full-time farm households	5.0	6.0	2.0	6.0	8.0	4.0	11.0	14.0	6.0
	Part-time farm households	5.0	4.0	8.0	9.0	7.0	11.0	14.0	11.0	19.0
	Regular farm workers	2.4	4.7	3.5	3.2	3.5	4.3	3.1	4.0	4.0
	Persons engaged in other jobs	0.7	0.4	0.8	1.3	0.7	1.3	1.1	0.6	1.1
Wages of other jobs (baht per day)		52.7	41.8	47.1	53.3	60.0	41.0	53.1	52.7	43.4
Age of the oldest household member		47.1	58.1	54.5	53.4	49.3	53.1	50.9	52.8	53.7

Note :1) Part-time farm household is defined as a farm household which has one or more household members engaged in other jobs than farming. Regular farm worker includes a household member who has been employed by others for 30 days and below.
2) I.E.R. symbols have the same meaning as in Table 1.

number of people in one household was around 6.

The percentage of the households engaged in full-time farming fell between 44 and 56 % in both intensive and extensive irrigated areas compared with only 24 % in the rain-fed area. 76 % of the households in the rain-fed area were engaged in part-time farming. This showed that in area that rely on rain-fed paddy field cultivation, subsistence by farming alone is very difficult.

The average number of full-time farmers in one household is 3 to 4 in all areas. The average number of part-time farmers per household was 0.6 to 1.1. The average, daily wage for non-agricultural labor was about 43 to 55 baht. In contrast, the daily wage for agricultural labor was around 35 baht. Most of the part-time non-agricultural work was temporary ; earthwork, carpentry, brick-laying, selling ice-cream, and construction work. Part-time labor in the agricultural sector was mainly seasonal work ; rice planting, harvesting, threshing and weeding.

On average, the oldest person in the farm household was about 50 years old. This shows that there were not many old people in Thailand's North-East Region.

Table 3 shows the levels of education of 219 local farmers above 13 years of age, the time when compulsory education ends. Children between 7 and 12 receive compulsory education at elementary school. The number of people in the survey who had not received any schooling was only 5 (2.3 % of the total number). All of them were above 65 years old. Most of the heads of the farm households graduated from elementary school (4 years of education in those days). However, 2 farmers in the rain-fed area had left school in their first and second grade respectively. All of the owner operator farmers didn't finish junior high school. Therefore, although there is no cases of illiteracy among the operator farmers, the overall level of education is not very high.

Table 3. Educational level of farm household members whose ages exceed 13 years (1985).

		I	E	R
Number of household members whose ages exceed 13 years		75	72	72
Household members who have not received school education	Number	2	3	0
	Average age	79	67	
School career of head	Up to elementary school 1st year	0	0	1
	Up to elementary school 2nd year	0	0	1
	Graduate elementary school 4th year	15	15	13
Educational level of children	Junior high school	0	1	0
	Graduate junior high school	1	3	0
	Graduate lower vocational school	0	0	2
	High school	1	0	0
	Graduate high school	5	0	1
	Graduate higher vocational school	1	0	0

Note : I.E.R. symbols have the same meaning as in Table 1

According to the results from the questionnaire, there are 8 people in the intensive irrigated area who have received higher education above the level of junior high school (3 years term). They are 2 junior high school graduates, 5 high school (3 years term) graduates and 1 higher vocational school (2 years term) graduate. In the extensive irrigated area, there are 4 people who have received higher education; 3 junior high school graduates and 1 student who at present is completing junior hight school. In the rain-fed area, the number is only 3 ; 2 lower vocational school (3 years term) graduates and 1 high school graduate. Overall, an improvement in the education level is important because it would help to improve the talent of individual children. Ultimately this would improve the economic welfare of the areas (Schultz, 1979).

The survey revealed that in the two irrigated areas, both large-scale and small-scale farm households could afford to give their children education above elementary school level. However, in the rain-fed area only large-scale households (cultivation acreage of 30-40 rai) could afford higher education for their children. It seems that the introduction of irrigation has made higher education affordable to most small-scale farm households in the irrigated areas.

In the agricultural villages of North-East Thailand, it is said that the father does not have much authority over his family. There also appears to be no discrimination towards the children, except that the older children are given authority over the younger ones (Mizuno, 1982). However, our survey results showed different. In actuality, there is some discrimination in the treatment of children according to their sex. The number of boys who have received higher education is 12, while the number of girls is only 3 (a ratio of 4 : 1).

Finally, male farmers in North-Eash Thailand usually enter their wife's family on marriage, and work the land jointly with their father-in-law. Later on in life, he leaves to set up his own, independent farm household (Miyazaki, 1985). This practice is still prevalent according to our survey. 16 of the 75 farm household heads answered in the survey that they were engaged in joint management with their daughter and her

husband (4 households in the intensive irrigated area, 5 in the extensive irrigated area, and 7 in the rain-fed area). There were only 2 households which were engaged in joint management with their son and his wife. This shows that household heads in North-East Thailand tend to live with their daughter's family rather than with their son's family.

2. Operated land, land price, land rent and types of tenancy

Table 4 shows the total acreage of operated land used in the intensive irrigated, extensive irrigated, and rain-fed areas respectively. The paddy fields in the three areas are similar in size, ranging from 14 to 18 rai. However, the acreage used for upland fields varies. For example, there was 0.3 rai of upland field used in the intensive irrigated area compared with 7 rai in the rain-fed area.

The total acreage of operated land in each area, including orchards and vegetable gardens, ranges from 16 to 2.5 rai. As table 4 shows clearly, the acreage of operated land is the smallest in the intensive irrigated area, which has the highest productivity. In the rain-fed area where irrigation has not been introduced, the acreage of operated land is the largest.

The acreage of leased land is small, as a clearly defined land-holding class and the practice of leasing to tenants has not as yet emerged. Paddy fields are leased more than upland fields. The paddy fields in the intensive irrigated area are the most productive and are easily leased. The paddy fields in the rain-fed area, because of their

Table *4.* Acreage of operated land per farm household.

		1984			1985			Two years average		
		I	E	R	I	E	R	I	E	R
Paddy field (rai)	Owned	13.35	20.10	17.40	13.1	14.9	17.1	13.2	16.98	17.22
	Rented in	1.20	0.40	0.20	1.6	0.67	0.47	1.44	0.56	0.36
	Total	14.55	20.50	17.60	14.7	15.57	17.57	14.64	17.54	17.58
Upland field (rai)	Owned	0.0	2.70	6.50	0.13	2.4	7.1	0.08	2.52	6.86
	Rented in	0.40	0.0	0.0	0.07	0.0	0.0	0.20	0.0	0.0
	Total	0.40	2.70	6.50	0.20	2.4	7.1	0.28	2.52	6.86
Orchard (rai)	Owned	0.90	0.10	0.0	0.6	0.73	0.94	0.72	0.48	0.56
	Rented in	0.13	0.0	0.0	0.0	0.0	0.0	0.05	0.0	0.0
	Total	1.03	0.10	0.0	0.6	0.73	0.94	0.77	0.48	0.56
Vegetable garden (rai)	Owned	0.20	0.05	0.0	0.38	0.06	0.0	0.31	0.06	0.0
	Rented in	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	0.20	0.05	0.0	0.38	0.06	0.0	0.31	0.06	0.0
Total acreage of operated land (rai)		16.18	23.35	24.1	15.88	18.76	25.61	16.0	20.6	25.0
Rented out (rai)	Paddy field	0.40	0.60	0.0	0.0	0.63	1.7	0.16	0.62	1.02
	Orchard	0.10	0.0	0.0	0.0	0.0	0.0	0.04	0.0	0.0

Note : 1) 1rai = 0.16ha.
2) I.E.R. symbols have the same meaning as in Table 1.

low productivity, are leased last.

Table 5 shows that the price for 1 rai acreage of paddy field ranges from 14,000 to 20,000 baht. The price of a paddy field in the intensive irrigated area is 1.4 times higher than paddy fields in the rain-fed area. The price of 1 rai of upland field is 12,000 to 16,000 baht. The transactions of agricultral land seldom take place. The change of ownership is done mostly through inheritance.

Rent for 1 rai acreage of paddy field is 270 baht in the rain-fed area, 350 in the extensive irrigated area, and 439 in the intensive irrigated area. (The above figures are taken from the average price in rent found in the two surveys). The rent paid for paddy fields in the intensive irrigated area is about 1.6 times higher than the paddy fields in the rain-fed area. The rent for a paddy field is set at 18 to 20 % of the actual land price (21.5 % for a field in the intensive irrigated area, 19.1 % for an extensive irrigated paddy field, and 18.6 % for a rain-fed paddy field). The price of land appears to be determined by the rate of rent. This rent rate (18 to 20 %) is almost the same as the rate of interest attached to a loan of money from a commercial bank in North-East Thailand (18 %). The rate of interest attached to a loan from a moneylender is 40 %; the rate of interest on a loan from the Bank for Agriculture and Agricultural Co-operatives is 14 %, and the interest rate for fixed deposit at commercial banks is 9 %.

A land is usually leased between relatives (approximately 70 %), and seldom between unrelated persons. The contract is usually verbal (approximately 70 %). The rent is usually a fixed sum and paid in cash (75 %). Rent payment in barter or kind

Table 5. Land price and land rent per rai and types of tenancy.

		1984			1985			Two years average		
		I	E	R	I	E	R	I	E	R
Land price (baht)	Paddy field	22,500	16,950	9,900	19,045	19,256	17,533	20.427	18,334	14,480
	Upland field	—	16,167	10,333	16,000	14.375	13,667	16,000	15,143	12,333
	Orchard	18,833	10,000	—	39,375	13,286	12,398	35,267	12,875	12,398
	Vegetable garden	21,667	10,000	5,000	35,000	20,000	—	29,286	15,000	5,000
Land rent (baht)	Paddy field	691	500	240	250	200	300	439	350	270
	Upland field	125		—		— —	— —	125		— —
	Orchad	633	—	—	—	—	—	633	—	—
Types of tenancy contract (number)	Oral	4	1	1	3	2	0	7	3	1
	Written	1	1	0	1	1	1	2	2	1
Kind of land rent (number)	Sharecropping	1	0	0	0	0	0	1	0	0
	Fixed in cash	3	1	1	3	3	1	6	4	2
	Fixed in kind	0	1	0	1	0	0	1	1	0
	Labor	1	0	0	0	0	0	1	0	0
Relation to land lord and tenant (number)	Relative	5	2	1	1	2	0	6	4	1
	Others	0	0	0	3	1	1	3	1	1

Note : I.E.R. symbols have the same meaning as in Table 1.

seldom occurs. In cases where rent is paid in kind, the landowner receives 40-50 % of the harvest.

3. Barns and agricultural implements ; number and capital value

Table 6 shows the number of barns and agricultural implements per farm household. The number of 2-wheel tractors per farm household is 0.52 in the intensive irrigated area, 0.32 in the extensive irrigated area, and only 0.12 in the rain-fed area. Most farm households in the rain-fed area keep buffaloes for the cultivation of their fields. In the intensive irrigated area, however, buffaloes have been mostly replaced by tractors. This has reduced the farmer's ploughing time considerably. The farm households which cannot afford a tractor often hire one to have their fields cultivated. The cost of cultivation by hired tractor is 200 baht per rai in both the intensive and extensive irrigated areas. The price of a 2-wheel tractor is about 22,000 bath, which is almost equivalent to the annual income of a farm household in the rain-fed area. It isn't hard to imagine thedifficultyfarmers in the rain-fed area face in their efforts to purchase a tractor. It will take a long time before buffaloes can be replaced by tractors in this area. Also, it is unlikely that the farmers in this area will be able to escape the vicious circle of poverty as they lack the means necessary for capital accumulation.

Threshers have not been introduced in any of the three area. Each farm household pays 60 to 70 baht per rai yearly in labor for thresing. Moreover, as most farm housholds have no means of carrying unhulled rice from the paddy fields to the storehouses, a further cost of about 15 baht per rai is paid in transporting costs.

Table 7 shows the capital value of barns and agricultural implements at the time of the survey. The net capital value of both barns and agricultural articles was a little more than 30,000 baht in the intensive irrigated area, 26,000 baht in the extensive irrigated area, and a little less than 10,000 baht in the rain-fed area. This shows that

Table 6. **Number of barns and agricultural implements per farm household.**

	1984			1985			Two years average		
	I	E	R	I	E	R	I	E	R
Barn	*0.5*	*0.7*	*0.8*	*0.73*	*0.87*	*0.53*	*0.64*	*0.80*	*0.64*
Warehouse	**1.1**	**0.9**	**0.9**	**1.07**	**0.93**	**1.4**	**1.08**	**0.92**	**1.20**
2-wheel **tractor**	**0.5**	**0.4**	**0.1**	**0.53**	**0.27**	**0.13**	**0.52**	**0.32**	**0.12**
Spray	**0.5**	**0.4**	**0.4**	**0.60**	**0.67**	**0.4**	**0.56**	**0.56**	**0.40**
Iron plow	**0.1**	**1.1**	**1.5**	**0.27**	**1.1**	**1.3**	**0.20**	**1.10**	**1.38**
Wooden plow	**0.0**	**0.2**	**0.0**	**0.07**	**0.0**	**0.2**	**0.04**	**0.08**	**0.12**
Sickle	**5.0**	**4.3**	**4.8**	**5.3**	**4.8**	**4.3**	**5.20**	**4.60**	**4.50**
Mill	**0.2**	**0.0**	**0.0**	**0.0**	**0.13**	**0.0**	**0.08**	**0.08**	**0.0**
Irrigation pump	**0.1**	**0.1**	**0.0**	**0.13**	**0.13**	**0.4**	**0.12**	**0.12**	**0.04**
Thresher	**0.1**	**0.1**	**0.0**	**0.07**	**0.0**	**0.0**	**0.08**	**0.0**	**0.0**
Weeder (Hoe)	**0.3**	**1.5**	**0.4**	**2.6**	**2.9**	**3.5**	**1.68**	**2.34**	**2.26**
Cart	**0.1**	**0.0**	**0.0**	**0.0**	**0.13**	**0.0**	**0.04**	**0.08**	**0.0**
Motor car	**0.1**	**0.1**	**0.0**	**0.13**	**0.13**	**0.0**	**0.12**	**0.12**	**0.0**
Motor cycle	**0.1**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.04**	**0.04**	**0.0**
Bicycle	**0.2**	**0.3**	**0.2**	**0.0**	**0.0**	**0.0**	**0.08**	**0.12**	**0.08**

Note : I.E.R. symbols have the same meaning as in Table 1

the farm households in the intensive irrigated area own about 3.4 times more capital goods than the households in the rain-fed area.

Table 8 shows the farm households classified under the methods they use to raise funds to build barns and to buy agricultural implements. The purchase of barns, warehouses and agricultural implements was mostly done by using personal savings. This is because agricultural finance is underdeveloped in North-East Thailand. The interest rate on a loan from the Bank for Agriculture and Agricultural Co-oeperatives was 14 %. This discouraged farm households from taking out loans. Some households in the rain-fed area borrowed money from private money lenders at an interest of 40 %, to buy thier own 2-wheel tractor. In the two irrigated areas, the money raised by the agricultural cooperatives was mostly used to buy 2-wheel tractors.

4. The amount, capital value and fund raising methods used for the purchase of livestock, poultry and fish

Table 9 shows the amount of livestock, poultry and fish raised per farm households. The farm households are classified by the way they raise funds to purchase livestock, poultry and fish.

As mentioned earlier, farm households in the rain-fed area mainly use buffaloes to cultivate their paddy fields. The number of buffaloes kept per farm household in this area was 2.4. The price of a buffalo is 5,000 to 7,000 baht. In contrast, farm households in the two irrigated areas mainly keep white-colored beef cattle of Brahman. On average, 1 head of cattle was kept per household. The cattle also produced manure which was used in the fields. For example, some households mainly used animal manure in their cultivation of rice and various kinds of vegetables. However, as the acreage of cultivated land was limited in the irrigated areas, the percentage of land allotted to grow fodder for cattle was small. Consequently, the indigenous farmers

Table 7. Capital value of barns and agricultural implements per farm household.

	1984 (baht)			1985 (baht)			Two years average (baht)		
	I	E	R	I	E	R	I	E	R
Barn	2,225	310	710	1,580	833	*1,103*	*1,838*	624	946
Warehouse	4,035	7,650	2,225	5,787	660	*6,900*	*5,086*	3,456	5,030
2-wheel tractor	9,000	8,270	2,700	10,467	6,253	*2,667*	*9,880*	7,060	2,680
Spray	2.425	52	31	145	165	*57*	*1,057*	120	47
Iron plow	15	151	179	27	158	*149*	*22*	155	161
Wooden plow	0	30	0	3	0	*35*	*2*	12	21
Sickle	153	102	103	113	85	100	129	92	101
Mill	1,500	0	0	0	12,667	0	600	7,600	0
Irrigation pump	200	12	0	267	533	1,140	240	325	184
Thresher	4,000	0	0	2,433	0	0	3,060	0	0
Weeder (Hoe)	22	154	28	120	131	183	81	140	121
Cart	40	0	0	0	6,667	0	16	4,000	0
Motor car	6,850	3,500	0	10,667	2,267	0	9,140	2,760	0
Total	30,465	20,231	5,976	31,609	30,419	12,334	31,151	26,344	9.291

Note : I.E.R. symbols have the same meaning as in Table 1.

Table 8. Number of farm households by method of raising fund for acquiring barns and agricultural implements.

		1984			1985			Two years total		
		I	E	R	I	E	R	I	E	R
Barn	Personal saving	3	6	8	9	9	8	12	15	16
	Relative loan	0	1	0	0	0	0	0	1	0
Warehouse	Persona1 saving	9	7	7	15	14	15	24	21	22
	Relative loan	0	1	0	0	0	0	0	1	0
	Gift from parents	0	1	2	0	0	0	0	1	2
Z-wheel tractor	Personal saving	2	4	0	6	2	2	8	6	2
	Agri. cooperative loan	3	0	0	2	0	0	5	0	0
	Money lender loan	0	0	1	0	0	0	0	0	1
Spray	Persona1 saving	5	4	4	9	10	5	14	14	9
Iron plow	Personal saving	1	8	10	3	12	13	4	20	23
Wooden plow	Personal saving	0	1	0	1	0	2	1	1	2
Sickle	Personal saving	10	10	10	15	15	14	2.5	25	24
Mill	Persona1 saving	2	0	0	0	1	0	2	1	0
	Relative loan	1	0	0	0	1	0	1	1	0
Irrigation pump	Personal saving	1	1	0	2	2	6	3	3	6
Thresher	Personal saving	1	0	0	1	0	0	2	0	0
Weeder (Hoe)	Personal saving	2	4	3	15	15	15	17	19	18
Cart	Personal saving	1	0	0	0	2	0	1	2	0
Motor car	Personal saving	1	1	0	1	1	0	2	2	0
	Agri. cooperative loan	0	0	0	1	1	0	1	1	0
	Relative loan	0	0	0	1	1	0	1	1	0

Note : I.E.R. symbols have the same meaning as in Table 1.

couldn't have large cattle herds. A further problem was the constant danger of the cattle breaking the earthen irrigation canals as they were tied to poles inserted in the earthen framework of the canals. Incidentally, one head of cattle cost 6,000 to 8,000 baht.

The reason why a large number of domestic fowls were kept in the intensive irrigated area was that certain farm households in this area were broiler households (4,000 fowls in total). In general, duck, fish and pigs were the main livestock kept in the two irrigated areas.

The funds for purchasing livestock was usually raised through personal savings, except in the few cases where a loan was made from the agricultural cooperatives in the rain-fed area. Table 10 shows the capital value of livestock, poultry and fish.

Table 9. Number of animals, poultry and fish per farm household, and number of farm households by method of raising fund for acquiring animals, poultry and fish.

			1984			1985			Average or total		
			I	E	R	I	E	R	I	E	R
Number per farm	Buffalo		0.2	1.8	2.4	0.67	2.10	2.4	0.48	1.98	2.40
	Cattle		0.0	0.3	0.0	1.53	1.40	1.1	0.92	0.96	0.66
	Hen		413.0	19.0	7.2	8.40	23.9	11.5	170.24	21.94	9.78
	Duck		0.0	24.7	3.2	23.50	6.9	1.7	14.10	14.02	2.30
	Pig		0.2	0.0	0.2	2.20	0.13	0.0	1.40	0.08	0.08
	Fish		100.0	120.0	0.0	533.3	833.3	173.4	359.9X	547.80	104.04
Number of farm household	Buffalo	Personal saving	1	4	8	1	11	12	2	15	20
		Gift from parents	0	3	2	2	0	0	2	3	2
		Relative loan	0	0	0	0	1	0	0	1	0
		Agri. cooperative loan	0	0	0	0	0	2	0	0	2
	Cattle	Personal saving	0	1	0	6	4	3	6	5	3
	Hen	Personal saving	4	6	4	8	13	12	12	19	16
		Gift from parents	1	2	0	1	0	0	2	2	0
		Money lender loan	1	0	0	0	0	0	1	0	0
	Duck	Personal saving	0	5	4	7	10	4	7	15	8
	Pig	Personal saving	2	0	1	4	1	0	6	1	1
	Fish	Personal saving	1	0	0	2	1	3	3	1	3
		Gift from parents	0	1	0	1	0	0	1	1	0

Note : I.E.R. symbols have the same meaning as in Table 1.

Table 10. Capital value of animals, poultry and fish per farm household.

	1984 (baht)			1985 (baht)			Two years average (baht)		
	I	E	R	I	E	R	I	E	R
Buffalo	800	9,240	11,180	3,800	8,800	14,300	2,600	8,976	13,052
Cattle	0	750	0	9,733	6,053	5,000	5,840	3,932	3,000
Hen	1,697	290	206	383	528	370	909	433	304
Duck	0	168	160	710	345	57	426	274	98
Pig	1,450	0	300	2,920	400	0	2,332	240	120
Fish	110	15	0	567	5,000	767	384	3,006	460
Total	4,057	10,463	11,846	18,113	21,126	20,494	12,491	16,861	17,034

Note : I.E.R. symbols have the same meaning as in Table 1.

5. Total acreage used for rice cultivation, annual rice yield per rai, and the price of rice

Double cropping (cropping in the dry season and in the rainy season) was feasible in the two irrigated areas. (We will refer to the method of cultivation of paddy-field

rice later). As Table 11 shows, glutinous rice is mainly cultivated in the rainy season, especially in the extensive irrigated area. The glutinous rice harvested during the rainy season was mainly used for domestic consumption. As priviously stated, a family of six members needs 2,000 kg of unhulled rice a year for domestic consumption. Taking the annual rice yield per rai as 400 kg, a minimun 5 rai per household is necessary for the production of rice for domestic use alone. Since 9 to 12 rai of glutinous rice per household is cultivated in the rainy season, half of the annual harvest of glutinous rice in the two irrigated areas is put up for sale. On the other hand, the annual yield of glutinous rice per rai in the rain-fed area was 280 kg. Consequently, a minimum area of 7 rai is necessary to produce the amount of rice required for domestic consumption.

The rice grown during the dry season was mostly non-glutinous. The total harvested acreage of rice per farm household was 26.3 rai in the intensive irrigated area, 24.5 rai in the extensive irrigated area, and 17.2 rai in the rain-fed area. The harvested acreage of the rain-fed area was the smallest because double cropping was impossible. Low productivity and a limited amount of cultivatable land are the two main reasons for the low level of agricultural income in the rain-fed area.

In both the intensive and the extensive irrigated areas, rice is grown twice a year. During both the dry and wet season, irrigation water is provided. However, the amount of water available is limited. Consequently, during the dry season especially, the acreage of irrigated land is small.

The rate of double cropping was taken as the land acreage used for rice harvest in the dry season against the land acreage used for rice harvest in the rainy season. Overall, 86.5 % (((10.8 + 1.4)/(4.9 + 9.2)) x 100) of the paddy fields was used twice per year in the intensive irrigated area, compared with 56.0 % (((6.4 + 1.5)/(2.1 + 12.0)) × 100) in the extensive irrigated area. This shows that the paddy field use is about 30 % higher in the intensive irrigated area than in the extensive irrigated area.

The rate of double cropping is useful in defining the land use rate of an individual paddy field. All land available for rice growing is used at least once during the rainy

Table 11. Total harvested acreage of rice per farm household.

			1984 (rai)			1985 (rai)			Two years average (rai)		
			I	E	R	I	E	R	I	E	R
Irrigated paddy field	Rainy season	Nonglutinous	2.8	0.6	—	6.3	3.1	—	4.9	2.1	—
		Glutinous	11.8	12.5	—	7.4	11.6	—	9.2	12.0	—
	Dry season	Nonglutinous	6.7	4.8	—	13.6	7.4	—	10.8	6.4	—
		Glutinous	3.5	1.2	—	0.0	1.7	—	1.4	1.5	—
Rain-fed paddy field	Rainy season	Nonglutinous	—	0.7	0.1	—	—	1.3	—	0.3	0.8
		Glutinous	—	5.6	16.3	—	—	16.0	—	2.2	16.1
Total harvested acreage			24.8	25.4	16.4	27.3	23.8	17.8	26.3	24.5	17.2

Note : I.E.R. symbols have the same meaning as in Table 1.

season. Therefore, the minimum land use rate is derived as being 100. The land use rate of a paddy field is derived by adding 100 to the rate of double cropping. In the intensive irrigated area, the land use rate of a paddy field was calculated as 186.5 % ; 156 % in the extensive irrigated area. Clearly, the land use rate of a paddy field in the intensive irrigated area is higher than that of the extensive irrigated area. Lastly, as rice is not grown during the dry season in the rain-fed area, the land use rate of a paddy field is the basic minimum rate of 100 %.

Nationally, the rate of double cropping in paddy field of 7 % was calculated from The Agricultural Statistics of Thailand (Ministry of Agriculture and Co-operatives, 1983). Moreover, the rate in North-East Thailand was calculated as being 0.8 %. The rate in Khon Kaen Prefecture came to 4.5 %, which was derived from the figures of 1982/83 crop year. These figures help to clearly illuminate the extremely high rate of double cropping in paddy field found in the two irrigated areas.

Table 12 shows the weight of unhulled rice harvested per rai. The yearly rice yield per rai in Thailand increased during the 1960's due to the increased use of fertilizers and the introduction of improved variety of rice. However since 1970, there has been little increase in rice production. The average rice yield per rai in the rainy season was 263 kg for the whole of Thailand, 187 kg for North-East Thailand, and 240 kg for Khon Kaen Prefecture (Ministry of Agriculture and Co-operatives, 1983). The main crop cultivated during the rainy season is glutinous rice. According to Table 12, the harvest of glutinous rice was 501.9 kg in the intensive irrigated area, 403.8 kg in the extensive irrigated area, and 281 kg in the rain-fed paddy area. (The average is taken from the 1984 and 1985 harvests). This shows that the yearly rice yield per rai in the intensive irrigated area is 1.8 times more than the rain-fed area. The annual yield per rai of non-glutinous rice was 473.3 kg in the intensive irrigated area, 429.6 kg in the extensive irrigated area, and 289.0 kg in the rain-fed area (the average from the 1984 and 1985 yields).

Table 12. Yield of paddy per rai, and its coefficient of variation of farm households.

				1984			1985			Two years average		
				I	E	R	I	E	R	I	E	R
Yield per rai (kg)	Irrigated paddy field	Rainy season	Non-glutinous	551.8	487.5	--	421.0	391.0	—	473.3	429.6	—
			Glutinous	530.4	355.5	—	482.9	436.0	—	501.9	403.8	—
		Dry season	Non glutinous	545.0	511.0	—	444.3	489.3	—	484.4	498.0	—
			Glutinous	566.7	517.0	—	—	250.0	—	566.7	356.8	—
	Rain fed paddy field	Rainy season	Nonglutinous	—	410.0	400.0	—	—	215.0	—	410.0	289.0
			Glutinous	—	316.0	199.1	—	—	335.6	—	316.0	281.0
CO efficient (%)	Irrigated paddy field	Rainy	Glutinous	25.5	49.2	—	30.1	36.1	—	28.3	41.3	—
		Dry	Non-glutinous	18.0	29.6	—	36.5	24.8	—	29.1	26.7	—
	All paddy fields			15.6	36.9	40.2	27.9	28.6	50.6	23.0	31.9	46.4

Note : I.E.R. symbols have the same meaning as in Table 1

In the case of North-East Thailand, the average rice yield per rai is around 7/10 of the national average. This is because the demand for new land has led into rice being grown in areas where conditions are poor for rice cultivation. However, the yearly rice yield per rai in the two irrigated areas is 1.5 to 2.0 times above the national average.

The national average yield per rai of rice grown during the dry season was 531 kg (the 1982/83 crop year). The average yield in North-East Thailand was 364 kg. In Khon Kaen Prefecture the 1982/83 average yield per rai was 400 kg. The main crop grown during the dry season was non-glutinous rice. According to Table 12, the yield per rai of non-glutinous rice was 484.4 kg in the intensive irrigated area, and 498.0 kg in the extensive irrigated area. These figures are lower than the national average. Rice cultivation in the dry season is possible only in irrigated areas. The yealy rice yield per rai in the Central Plain Region is 555 kg, by far the highest in the whole Thailand. This is why the national average of the yearly rice yield per rai in Thailand is higher than the average rice yield in the two irrigated areas in question.

The coefficient of variation of the yearly rice yield per rai among individual farm households taken on a scale of 100 was 23 % in the intensive irrigated area, 31.9 % in the extensive irrigated area, and 46.4 % in the rain-fed area (the average of the 1984 and 1985 yield). The figures show that rice production in the intensive irrigated area does not vary greatly among individual farm households.

Once harvested, the rice is sold to local merchants (brokers), who carry the rice to milling factories. There, the rice (unhulled) is classified according to quality. The classified rice is sold to wholesale dealers, and then to retail sellers, who in turn sell the rice to the consumer. Since 1982, the price of rice per kg in Thailand has been steadily dropping. This has been due to the increase in rice production in Indonesia which had imported the largest amount of rice from Thailand, and the good harvests in the U. S. A., Burma and Pakistan, the main rival rice-exporting nations (Kuriya, 1982). Table 13 reflects the decrease in rice prices between 1984 and 1985. The average price of unhulled rice per kg in 1984 and 1985 was between 2.45 and 2.53 baht.

Table 13. Price of paddy per kilogram.

			1984 (baht)			1985 (bath)			Two years average (baht)		
			I	E	R	I	E	R	I	E	R
Irrigated paddy field	Rainy season	Nonglutinous	2.88	2.48	—	2.61	2.62	—	2.72	2.56	—
		Glutinous	2.49	2.57	—	2.10	2.17	—	2.26	2.33	—
	Dry season	Non -glutinous	2.55	2.85	—	2.50	2.67	—	2.52	2.74	—
		Glutinous	2.61	2.47	—	—	1.65	—	2.61	1.98	—
Rain-fed paddy field			—	2.60	2.90	—	—	2.50	—	2.60	2.66
	Rainy season	Nonglutinous	—	2.60	2.60	—	—	2.0	—	2.60	2.24
		Glutinous									
All paddy fields			2.63	2.60	2.75	2.40	2.28	2.25	2.53	2.47	2.45

Note : I.E.R. symbols have the same meaning as in Table 1.

6. Income from rice cultivation, agriculture diversification, and agricultural income

Table 14 shows the average household income obtained from rice production in the dry and rainy seasons according to the three respecive areas. These figures were derived by subtracting the running costs from the gross income. However, these figures do not account for capital depreciation. Therefore, it must be noted that these figures are modified and do not actually represent the exact rice harvest income.

In table 14, the average household incomes obtained from rice production in both the dry and rainy seasons for the intensive irrigated area were almost the same. The income came to 21,758 baht. In the extensive irrigated area, the average household rice harvest income in the rainy season was higher than that of the dry season. The annual income from rice production in the intensive and extensive irrigated areas were almost the same.

As cultivation during the dry season is impossible in the rain-fed area, income from rice comes in only 6 months of a year. The average income from rice production per household in this area was 7,436 baht. The average income from rice production per household in the whole Thailand in 1980 and 1981 was 7,613 baht, the average for the North-East Region was 5,416 baht (Ministry of Agriculture and Co-operatives, 1983). Clearly, the rice harvest income in the surveyed rain-fed area is higher than the average rice harvest income of North-East Thailand, and close to the national average.

Table 15 shows the agricultural income per household exclusing rice production. Agricultural income excluding rice is classified into two categories ; the income gained from upland field crops, fruits and vegetable, and the income gained from livestock,

Table 14. Income from rice per farm household.

		1984			1985			Two years average		
		I	E	R	I	E	R	I	E	R
Irrigated paddy field										
Rainy season	Total yield (kg)	7,837	4.420	—	5,973	8,447	—	6,719	6,836	—
	Gross income (baht)	20,006	11,465	—	14,187	19,645	—	16,515	16,373	—
	Expenditures (baht)	4,872	1,255	—	5,024	4,396	—	4,963	3,140	—
	Income (baht)	15,134	10,210	—	9,163	15.249	—	11,552	13,233	—
Dry season	Total yield (kg)	5,524	2,730	—	5,655	4,122	—	5,603	3,565	—
	Gross income (baht)	14,299	7,666	—	14,579	10,498	—	14,467	9,365	—
	Expenditures (baht)	4,102	858	—	4,367	3,224	—	4,261	2,278	—
	Income (baht)	10,197	6,808	—	10,212	7,274	—	10,206	7,087	—
Rain-fed paddy field										
Rainy season	Total yield (kg)	—	1,620	3,260	—	—	4,642	—	648	4,089
	Gross income (baht)	—	4,224	8,684	—	—	9,604	—	1,690	9,236
	Expenditures (baht)	—	730	1,115	—	—	2,256	—	292	1,800
	Income (baht)	—	3,494	7,569	—	—	7,348	—	1,398	7,436
Total	Gross income (baht)	34,305	23,355	8,684	28,766	30,143	9,604	30,982	27,428	9,236
	Expenditures (baht)	8,974	2,843	1,115	9,391	7,620	2,256	9,224	5,710	1,800
	Income (baht)	25,331	20,512	7,569	19,375	22,523	7,348	21,758	21,718	7,436

Note : I.E.R. symbols have the same meaning as in Table 1

poultry and fish. Of all the upland field crops, fruits and vegetables cultivated in the extensive irrigated and rain-fed area, cassava provided the largest income of return. However, in the intensive irrigated area, cassava is not cultivated because there are not many upland fields. The average household income obtained from growing cassava in the rain-fed area was 1,680 baht.

The income from the remaining upland fields crops (chili, squash, eggplant, tomato, soybean, celery, longbean, cucumber, banana, papaya, mango, lemon) was the largest in the extensive irrigated area at 12,090 baht per household (the 1984 and 1985 yield average). The high return shown in this area was due to the practice of intensive cultivation in small vegetable garden plots.

The income from livestock, poultry and fish per household in Table 15 is the sum of all returns ; i. e. chicken, duck, pig, beef cattle, buffalo and fish. The income obtained from livestock farming was 2,788 baht =(399+2,389) in the intensive irrigated area, 1,557 (= 56 + 1,501) in the extensive irrigated area, and 1,102 (= 43 + 1,059) in the rain-fed area. The national average household income from livestock farming was 3,220 baht compared with 2,777 baht for the North-East Region. The income obtained from livestock farming in the three areas was clearly lower than the national average.

In short, the agricultural income (excluding rice production) per household was the

Table 15. Income from crops, livestock, poultry and fish other than rice per farm household.

		1984			1985			Two years average		
		I	E	R	I	E	R	I	E	R
Upland field crops, fruits and vegetables										
Cassave	Total yield (kg)	0	900	1,300	0	1,217	3,933	0	1,090	2,880
	Gross income (baht)	0	680	940	0	840	2,717	0	776	2,006
	Expenditures (baht)	0	220	250	0	262	377	0	245	326
	Income (baht)	0	460	690	0	578	2,340	0	531	1,680
Others	Gross income (baht)	5,818	1,035	930	3,220	20,436	6,344	4,259	12.676	4,178
	Expenditures (baht)	1,119	282	660	977	789	2,223	1,034	586	1,598
	Income (baht)	4,699	753	270	‘2,243	19,647	4,121	3,225	12,090	2,580
Livestock, poultry and fish										
Layers broilers	Total Gross income (baht) head (head)	398.3	2.8	1.4	3.7	1.3	1.0	161.5	1.9	1.2
	Expenditures (baht)	9,309	84	47	158	47	45	3,818	62	46
	Income (baht)	8,531	8	4	11	4	3	3,419	6	3
		778	76	43	147	43	42	399	56	43
Others	Gross income (baht)	2,650	560	500	5,775	6,530	1,600	4,525	4,142	1,160
	Expenditures (baht)	1,519	355	3	2,547	4,165	167	2,136	2,641	101
	Income (baht)	1,131	205	497	3,228	2,365	1,433	2,389	1,501	1,059
Total	income (baht)	6,608	1,494	1,500	5,618	22,633	7,936	6,013	14,178	5,362

Note : 1) Others of upland field crops, fruits and vegetables include chili, squash, eggplant, tomato, soybean, celery, longbean, cucumber, banana, papaya, mango, lemon and so forth. Others of livestock, poultry and fish include duck, pig, beef cattle, buffalo, fish and so forth.

2) I.E.R. symbols have the same meaning as in Table 1.

highest in the extensive irriaged area, with 14,178 baht, followed by the intensive irriaged area, with 6,013 baht. The rain-fed area displayed the lowest income return with 5,362 baht.

The agricultural income per household for all areas is shown in Table 16. The figures are the sum of the income obtained from the rice harvest, the upland vegetable gardens and selling of animals. As the Table shows clearly, the total agricultural income is 27,771 baht in the intensive irrigated area, 35,896 baht in the extensive irrigated area, and 12,798 baht in the rain-fed area. The difference in agricultural income between the extensive and intensive irrigated areas is primarily due to the larger income of the upland fields in the former area. The agricultural income per household in Thialand is 23,207 baht ; 15,057 baht for the North-East Region (Ministry of Agriculture and Co-operatives, 1983). Undisputably, the household agricultural income of the two irrigated areas is higher than the national average, clearly highlighting that the two irrigated areas have undergone agricultural development.

The portion of the agricultural income not related to rice production can be regarded as an index to the extent in which farming diversification has occurred, The diversification percentage was 21.7 % in the intensive irrigated area, 39.5 % in the extensive irrigated area, and 41.9 % in the rain-fed area. The farming diversification percentage for Thialand and the North-East Region is 67.2 %(=(23,207−7,613)/23,207), and 64.0 %(=(15,057−5,416)/15,057), respectively. These figures show that the two irrigated areas have shown little inclination to diversify their crops. The agricultural development achieved so far in the two irrigated areas has been mainly in rice cultivation. As rice prices are unlikely to rise any further, in the near future new kinds of crops should be introduced out of economic necessity. However, the present irrigation system makes it difficult to irrigate paddy fields separately. This is a major deterrent in developing mixed crop production. It is especially difficult in the extensive irrigated area where plot-to-plot irrigation is still carried out.

It must be noted that the agricultural income unrelated to rice production in the two irrigated areas does not serve as an index for farming diversification. The reason is that income obtained apart from rice production was not gained by diversified use of the paddy fields, but mainly through the cultivation of vegetable gardens.

7. Part-time jobs and farm household income

Most farmers in the three areas are also engaged in part-time jobs. These jobs can be divided into two catagories. One is seasonal agricultural job like rice planting,

Table 16. Agricultural income and income of farm household per farm household.

	1984 (baht)			1985 (baht)			Two years average (bath)		
	I	E	R	I	E	R	I	E	R
Agricultural income	31,939	22,006	9,069	24,993	45,156	15,284	27,771	35,896	12,798
Income from other jobs	5,300	407	4,020	9,588	4,014	12,617	7,873	2,571	9,178
Income of farm household	37,239	22,413	13,089	34,581	49,170	27,901	35,644	38.467	21,976

Note : I.E.R. symbols have the same meaning as in Table 1

threshing, winnowing, weeding and harvesting. The other is non-agricultural job, such as carpentry, brick-laying and construction work. The income per household from part-time jobs is 7,873 baht in the intensive irrigated area, 2,571 baht in the extensive irrigated area, and 9,178 baht in the rain-fed area (the figures are from the average of the 1984 and 1985 survey).

At the time of survey, the national average part-time jobs income per household was 11,330 baht ; 9,618 baht for the North-East Region. The average part-time jobs income for the rain-fed area was close to the region level. However, the figures for both the intensive and extensive irrigated areas fall far short. The small income obtained from part-time jobs by households in the extensive irrigated area shows that farmers in this area concentrate mainly on agricultural labor.

The average farm household income, that is, the sum of the agricultural and the part-time income was 35,644 baht in the intensive irrigated area, 38,467 baht in the extensive irrigated area, and 21,976 baht in the rain-fed area (the average taken from 1984 and 1985 figures). The national average income for a farm household was 34,537 baht, but only 24,675 baht in the North-East Region. The average income of a farm household in the two irrigated areas was higher than the national average. It can safely be said that this was due to the agricultural development that has occurred in the area because of investment in irrigation.

8. Institutions and the agricultural economic environment

In order to achieve agricultural development through investment in irrigation, the agricultural sector and its constituent institutions have to be vastly improved. The establishment of irrigation associations and the improvement of the agricultural extension system is especially important (Suwit. 1977).

Table 19 shows the overall result of our surveys concerning the socio-economic problems. (Table 17 and Table 18 show the results of the separate surveys taken in 1984 and 1985). There was only one household which did not belong to a irrigation association. This shows that a system to regulate an adequate distribution of irrigation water had been successfully developed in the two irrigated areas. There were 177 irrigation associations in the Nong Wai District.

Membership in the Nong Wai Agricultural Cooperative Society was moderate, however. Only 50 to 60 % of the farm households in the two irrigated areas joined the society, despite the Agricultural Cooperative Society's many merits ; i. e. spreading agricultural irrigation techniques, acting as a mediator in the sale of farm products, the purchase of fertilizers and pesticides, and as a source of finance for its members. Similarly, in the rain-fed area, only 50 to 60 % of the households joined the Cooperative Society. The reason is probably that the Nong Wai Agricultural Cooperative Society has not yet been able to give the above mentioned advantages fully to the members, compared with the merchants.

Despite a large staff of 13, the Nong Wai Agricultural Cooperative Society had a limited number of trucks and threshers available for use. The Cooperative Society can only collect about 1.2 % (320 ton) of the total amount of rice produced in the Nong Wai District (about 27,000 ton). To meet this demand for harvest utilities, independent merchants bring threshers into the farm land by trucks to collect the harvest. From all the farm households in the Nong Wai District (about 5,000 households), 2,512 (about

Table 17. Socioeconomic problems and environment (1984)

Question		Reply	I	E (number)	R
Irrigation association		Member	10	10	
		Non-member	0	0	–
Agricultural cooperatives		Member	9	4	2
		Nonmember	1	6	8
Enough and timely use of irrigation water	Rainy season	Possible	9	8	–
		Impossible	1	2	–
	Dry season	Possible	6	5	
		Impossible	4	5	–
Sources of agricultural information		Extension worker	10	6	4
		Radio	2	1	1
		Magazine	0	2	0
		Neighbor	1	2	5
		Personal experience	2	1	1
Main factor of improvement in productivity		Fertilizer	10	9	10
		Water	1	3	5
		Seed	2	1	0
		Pesticide	1	1	1
		Insecticide	1	1	0
		Herbicide	1	2	6
Timely hire of agricultural implements		Possible	7	3	–
		Impossibl	2	3	–
Methods of raising fund for acquiring agricultural inputs		Agri. cooperatives	3	1	1
		Money lender	2	1	0
		Neighbor	0	2	1
		Relative	0	2	0
		Commercial bank	0	0	1
Reason for having no irrigatian facilities		In high place		–	6
		Far from canal	–	–	4

Note : 1) Overlapping replies are included.
2) I.E.R. symbols have the same meaning as in Table 1

50 %) had joined the Nong Wai Agricultural Cooperative Society. Although the Cooperative Society sold fertilizers at a cheaper price, most farm households bought fertilizers from the merchants because the Cooperative Society lacked the means to deliver the fertilizer to them.

The distribution of irrigation water was at times insufficient. In the questionnaire, 6 households out of the 25 in the intensive irrigated area, and 3 out of the 25 households in the extensive irrigated area answered that they didn't receive sufficient water even in the rainy season. As for the dry season, more than half of the households in the intensive irrigated area complained of insufficient water supply. The water shortage in the dry season is the most serious problem for the local farmers.

Table 18. Socioeconomic problems and environment (1985).

Question		Reply	I	E (number)	R
Irrigation association		Member	14	15	
		Nonmember	1	0	–
Agricultural cooperatives		Member	6	8	10
		Non-member	9	7	5
Enough and timely use of irrigation water	Rainy season	Possible	10	14	
		Impossible	5	1	–
	Dry season	Possible	5	12	
		Impossible	10	3	–
Sources of agricultural information		Extension worker	14	13	9
		Radio	2	3	1
		Magazine	0	0	0
		Neighbor	5	4	4
		Personal experience	1	1	2
Main factor of improvement in productivity		Fertilizer	15	13	14
		Water	7	7	4
		Seed	0	1	1
		Pesticide	0	0	0
		Insecticide	3	6	1
		Herbicide	0	0	0
Timely hire of agricultural implements		Possible	3	2	–
		Impossible	9	5	–
Methods of raising fund for acquiring agricultural inputs		Agri. cooperatives	4	2	4
		Money lender	1	1	1
		Neighbor	1	1	0
		Relative	1	2	1
		Commercial bank	5	0	0
Reason for having no irrigation facilities		In high place	–		12
		Far from canal	–	–	5
Multiple use of irrigation water		Multiple use	12	12	–
		Irrigation only	3	3	–
Television		Have	7	8	6
		Do not have	6	7	9

Note : 1) Overlapping replies are included.
2) I.E.R. symbols have the same meaning as in Table 1.

The agricultural extension service in all three areas was the main agent in introducing new farming techniques. Although extension service system has developed, some households still obtain their information primarily from their neighbors. If agricultural development is to continue, it is desirable that the extension service should be spurred further. The extension service workers encourage produc-

Table 19. Socioeconomic problems and environment (two years total).

Question		Reply	I	E (number)	R
Irrigation association		Member	24	25	–
		Non member	1	0	
Agricultural cooperatives		Member	15	12	12
		Non-member	10	13	13
Enough and timely use of irrigation water	Rainy season	Possible	19	22	
		Impossible	6	3	
	Dry season	Possible	11	17	
		Impossible	14	8	–
Sources of agricultural information		Extension worker	24	19	13
		Radio	4	4	2
		Magazine	0	2	0
		Neighbor	6	6	9
		Personal experience	3	2	3
Main factor of improvement in productivity		Fertilizer	25	22	24
		Water	8	10	9
		Seed	2	2	1
		Pesticide	1	1	1
		Insecticide	4	7	1
		Herbicide	1	2	6
Timely hire of agricultural implements		Possible	10	5	
		Impossible	11	8	
Methods of raising fund for acquiring agricultural inputs		Agri. cooperatives	7	3	5
		Money lender	3	2	1
		Neighbor	1	3	1
		Relative	1	4	1
		Commercial bank	5	0	1
Reason for having no irrigation facilities		In high place			18
		Far from canal			9
Multiple use of irrigation water		Multiple use	12	12	
		Irrigation only	3	3	
Television		Have	7	8	6
		Do not have	6	7	9

Note : 1) Overlapping replies are included.
2) I.E.R. symbols have the same meaning as in Table 1.

tion diversification by instructing the local farmers how to cultivate new crops like soybeans, peanuts, Chinese cabbage, red peppers and lettuce.

In the North-East Region, one extension service worker usually looks after **1,000** farm households. However, in the two irrigated areas, 500 farm households are looked after by one extension service worker. The smallest unit which a low ranking

extension worker administrates is a ward or "Tambon". The worker selects one out of every ten farm households in his Tambon as a contact farmer in order to help him perform his duties. Muang County (Amphoe) has 15 Tambons and 177 villages (Mubans), which holds 24,679 farm households. The 2,467 contact farmers are selected as the leaders in villages.

The extension worker in charge of the individual Tambons and the county head worker meet every two weeks. The workers in charge of the counties also meet with the prefectural extension workers once a month to compare notes. In this way information between the extension service headquarters and individual workers is kept update.

It seems that farmers in the survey areas regards fertilizing and water use as the key factors in improving productivity. The amount of domestic consumption of chemical fertilizers in Thailand has increased greatly since 1960. The rate has been especially dramatic since 1965. Domestic fertilizer production began in 1967.

The government's agricultural officers advise that ideally 25 kg of fertilizer per rai should be used. However, the actual fertilizer applied is only 12 kg per rai. The current price of fertilizer (the ratio of nitrogen, phosphoric acid and potassium is 16 : 20 : 0) is 4.2 baht per kg at the Nong Wai Agricultural Cooperative Society, and 5 baht if bought through a retail merchant. The fertilizers with an ratio of 16 : 16 : 8 cost 4.2 baht per kg at the Cooperative Society, and 5.8 baht when purchased from a retail merchant. Urea costs 2.4 baht.

At present, fertilizer prices are going up while rice prices are going down. Therefore, it is unlikely that the amount of fertilizers applied by farmers will increase remarkably. Five years ago unhulled rice and fertilizer cost both 3 baht per kg. However, last year unhulled rice cost 2.6 baht per kg and fertilizer 4 baht per kg. Over the space of 5 years, the relative price of fertilizer has increased 1.5 times more than that of unhuled rice.

The shortage of agricultural implements is strikingly obvious. More than half of the farm household answered in the questionnaire that they couldn't hire agricultural implements when needed.

The local farm households in the three areas mainly apply to the Agricultural Cooperative Society for loans to buy their materials for agricultural production. However, there are still some households which borrow money from commercial banks or private money lenders.

The irrigation water is not only used for farming but also for everyday use i. e. washing clothes and as drinking water for domestic animals.

A television set is possessed by most households. Television and raido are their main sources of information available on current topics and social problems. Printed information such as magazines and newspapers are rare (Kitahara, 1985).

9. An analysis of the influential factors in rice yield -the calculation of production elasticity-

(1) The input level of labor hours, fertilizers cost and cash expenditures

The annual rice yield per rai is determined by the household's labor, fertilizers cost and other cash expenditures. Table 20 shows the average amount of labor, fertilizers cost and other cash expenditures per rai invested by a household for rice production

in 1985. The labor time spent on glutinous rice production in the rainy season was 149.1 hours in the intensive irrigated area, 132.7 in the extensive irrigated area, and 105.1 hours in the rain-fed area. The cash expenditures were 418.5 baht in the intensive irrigated area, 306.4 baht in the extensive, and 157.5 baht in the rain-fed area.

As Table 12 shows, the glutinous rice yield per rai was 501.9 kg in the intensive irrigated area, 403.8 kg in the extensive irrigated area, and 281 kg in the rain-fed area.

(2) The correlation analysis of the rice yield per rai and the amount of labor hours,

Table 20. Inputs of rice production per rai (1985).

				Working hours (hour)			Fertilizers cost (baht)			Cash expenditures (baht)		
				I	E	R	I	E	R	I	E	R
Paddy field	Irrigated	Rainy season	Non glutinous	133.4	112.3	—	47.4	33.5	—	341.1	323.7	—
			Glutinous	149.1	132.7	—	67.3	30.6	—	418.5	306.4	—
		season	Non glutinous	97.6	153.9	—	100.3	72.3	—	316.3	369.7	—
			Glutinous	—	140.3	—	—	45.5	—	—	319.5	—
	Rain-fed	Rainy season	glutinous	—		117.0	—		13.5	—	—	58.7
			Glutinous	—		105.1	—		38.1	—	—	157.5

Note : I.E.R. symbols have the same meaning as in Table 1.

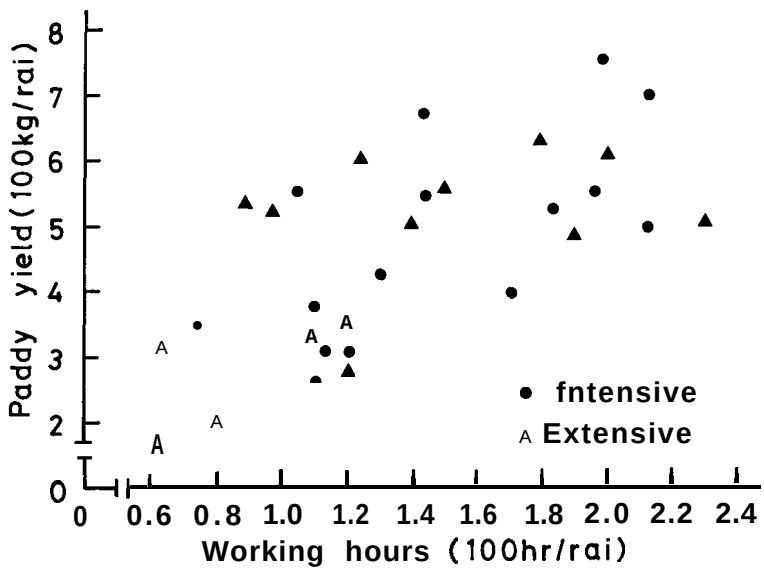

Fig. 2. Relationship between paddy yield and working hours per rai in irrigated areas (rainy season, glutinous, 1985).

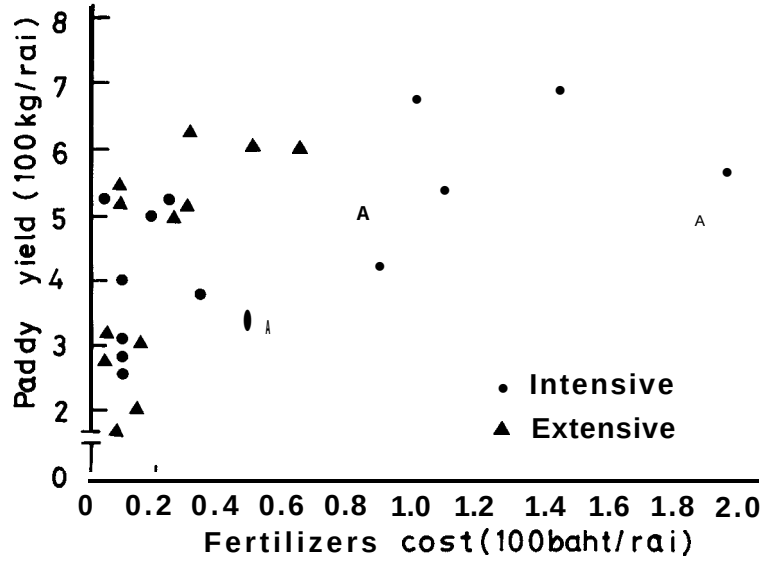

Fig. 3. Relationship between paddy yield and fertilizers cost per rai in irrigated areas (rainy season, glutinous, 1985).

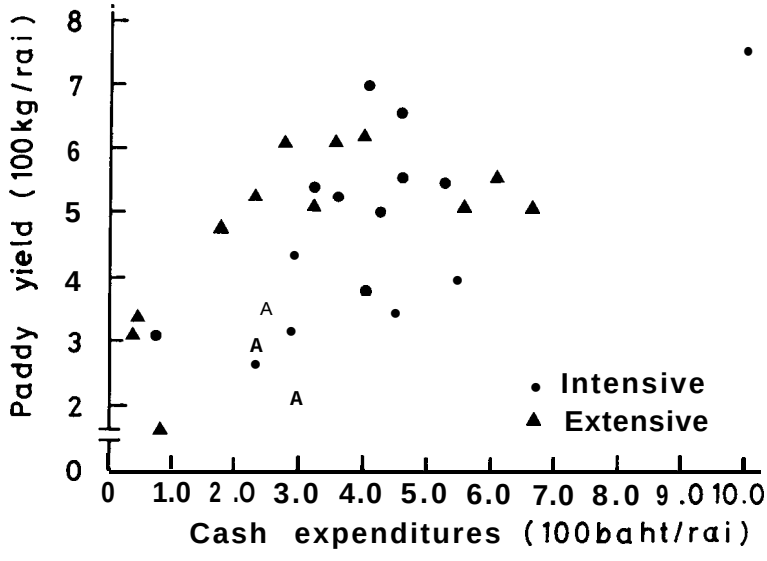

Fig. 4. Relationship between paddy yield and cash expenditures per rai in irrigated areas (rainy season, glutinous, 1985).

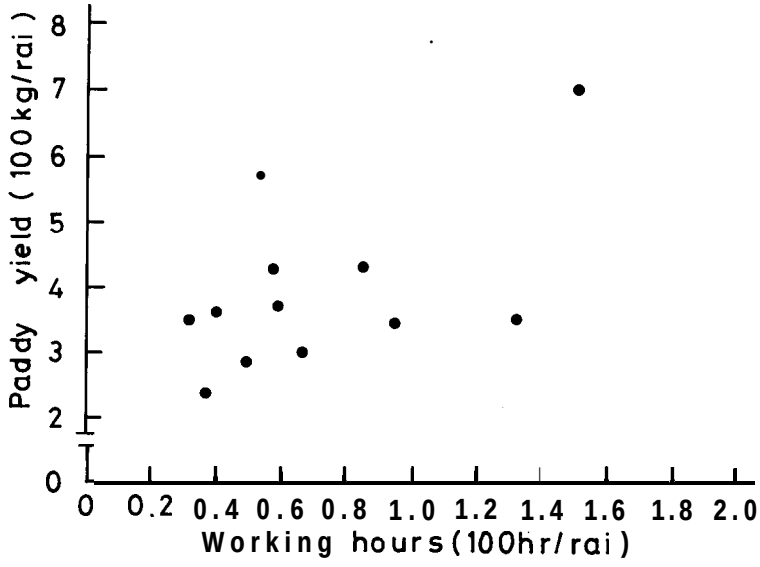

Fig. 5. Relationship between paddy yield and working hours per rai in intensive irrigated area (dry season, non-glutinous, 1985).

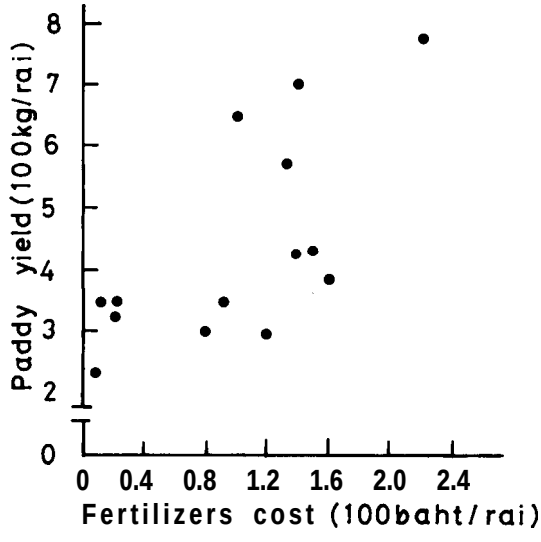

Fig. 6. Relationship between paddy yield and fertilizers cost per rai in intensive irrigated area (dry season, non-glutinous, 1985).

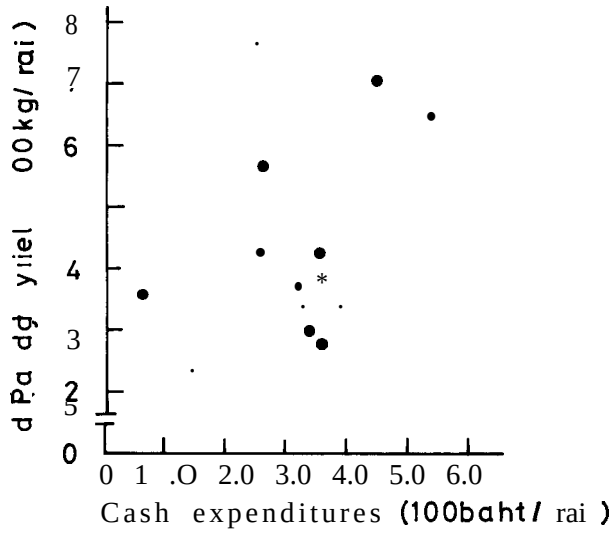

Fig. 7. Relationship between paddy yield and cash expenditures per rai in intensive irrigated area (dry season, non-glutinous, 1985).

fertilizers cost and other cash expenditures invested by farm households in rice production.

As we will explain later in further detail, direct sowing is not employed for glutinous rice production in the rainy season. Therefore, the amount of rice produced per rai correlated directly to the number of labor hours invested. Namely, production increases with labor intensity. Fig. 2 illustrates the correlation between the glutinous rice yield per rai in the rainy season and the number of labor hours invested (each dot denotes a household). As a rough rule, the more labor hours invested the greater the rice yield per rai becomes.

Fig. 3 correlates glutinous rice yield per rai in the two irrigated areas during the rainy season with fertilizers cost. Fig. 4 shows the correlation between rice yield and cash expenditures. Each dot denotes a farm household. In both Figures, the dots are spread haphazardly from bottom left to top right.

Fig. 5, 6 and 7 show the correlations between non-glutinous rice yield per rai in the intensive irrigated area during the dry season and the labor hours, fertilizers cost, and other cash expenditures invested respectively. Since some farm households in the intensive irrigated area use direct showing methods for non-glutinous rice production in the dry season, the rice yield per rai is not in equal proportion with the amount of labor hours, fertilizers and other cash expenditures invested. Overall, the more labor hours, fertilizers and other cash expenditures invested the greater the rice yield per rai becomes. This shows that production increases with labor intensity.

Table 21 shows the correlation coefficients between rice yield per rai (glutinous in the rainly season and non-glutinous in the dry season) and labor hours, fertilizers cost and other cash expenditures. The last row shows the correlation coefficients between

Table 21. Correlation coefficient between paddy yield and input per rai (1985).

		Rainy season			Dry season
		Glutinous			Nonglutinous
		I	E	R	I
Working hours		0.643 (0.010)	0.612 (0.015)	0.421 (0.119)	0.624 (0.017)
Fertilizers cost		0.741 (0.002)	0.456 (0.088)	0.531 (0.042)	0.661 (0.010)
Cash expenditures	Exclude fertilizers	0.657 (0.008)	0.515 (0.049)	0.710 (0.003)	0.237 (0.415)
	Total	0.769 (0.001)	0.545 (0.036)	0.703 (0.003)	0.320 (0.265)

Note :1) Figures in parenthesis show significance levels.
2) I.E.R. symbols have the same meaning as in Table 1.

rice yield and the total expenditures invested in production. The correlation coefficient between rice yield and labor hours is the highest in the intensive irrigated area (0.634) during the rainy season when glutinous rice is cultivated. It is lowest (at 0.421) in the rain-fed area. The correlation coefficient of rice yield per rai and fertilizers cost is the highest (0.741) in the intensive irrigated area when glutinous rice is produced during the rainy season.

The correlation analysis has shown that an increase in labor hours, fertilizers cost and other cash expenditures brings about a considerable increase in production.

(3) The effects of labor intensification and fertilizer increase

We have calculated the anticipated increase in rice production from the increase in the overall number of labor hours, fertilizers cost and other cash expenditures invested by using the production function. The model used to calculate glutinous rice production during the rainy season is as follows. The model has linear logs in both sides (Tsuchiya, 1976).

$$\text{Log } (Y/T) = \alpha + \beta \text{ Log } (L/T) + \gamma \text{ Log } (K/T)$$

Where Y denotes rice yield ; T the acreage paddy cultivation ; L stands for labor hours and K for fertilizers cost in the intensive irrigation area but for cash expenditures in the other two areas.

Table 22 shows the results of the calculations. In the intensive irrigated area, the production elasticity in labor hours is 0.551 ; 0.142 for fertilizers cost. As the total production elasticity is assumed as being 1, the production elasticity for the farm land is 0.307. Therefore, one can safely assume that if labor hours increased by 10 % per farm household in the intensive irrigated area during glutinous rice production in the rainy season, total production would increase by 5.51%. A 10 % increase in the amount of fertilizers invested would increase production by 1.42 %. The above calculations show vividly the labor intensification and increase in fertilizer use can have a good effect on production of rice.

Table 22. Production elasticities of glutinous rice (rainy season, 1985).

	I	E	R	Whole
Constant term	1.257	0.713	1.329	1.027
Working hours	0.551 (3.557)	0.718 (2.505)	0.243 (0.793)	0.452 (3.022)
Fertilizers cost	0.142 (3.850)	– –		– –
Cash expenditures	– –	0.161 (1.141)	0.316 (2.694)	0.259 (4.145)
R^2	0.735	0.521	0.486	0.571

Note : 1) The model is as follows :

$$\log\left(\frac{Y}{T}\right) = \alpha + \beta \log\left(\frac{L}{T}\right) + \gamma \log\left(\frac{K}{T}\right)$$

where Y is yield, T acreage of paddy cultivation, L working hours, and K fertilizers cost in intensive irrigated area or cash expenditures in other areas. Figures in parenthesis show t-values.

2) I.E.R. symbols have the same meaning as in Table 1.

Marginal productivity of labor can be calculated by multiplying production elasticity by the average productivity per hour. The average productivity of glutinous rice per hour during the rainy season in the intensive irrigated area was calculated by using the coefficients shown in Table 12, 13 and 20. 501.9 X 2.26/149.1 = 7.61. The marginal productivity of labor per hour is calculated by multiplying 7.61 by the production elasticity (0.551). That comes to 4.2 baht per hour. The marginal productivity of labor per day was 33.6 baht (= 4.2 × 8 hours). Generally, the average wage for an agricultural labor was 35 baht per day. Clearly, the marginal productivity of labor is equivalent to the average wage for an agricultural labor.

Next we will show the marginal productivity of fertilizers cost. The average productivity of fertilizers cost comes to 16.9 (= 501.9 X 2.26/67.3). When this is multiplied by the production elasticity (0.142), it comes to 2.4 baht. 1 baht of fertilizers produces 2.4 baht of gross income or 1.4 baht of net income. Accordingly, it is clear that fertilizers have scarcity value. Table 19 has already shown that many farm households considered the introduction of fertilizers to be the main factor in their production increase. The results of the calculation reinforce the effects an increase in fertilizer use has on production.

(4) Water use and the effects on production

The main crop grown in the dry season was non-glutinous rice. The production function of non-glutinous rice cultivation during the dry season in the intensive irrigated area is as follows :

$$\text{Log}\ (Y/T) = \alpha + \beta\ \text{Log}\ (L/T) + \gamma\ \text{Log}\ (F/T) + \delta D$$

where Y denotes rice yield ; T the acreage of paddy fields under cultivation ; L stands for labor hours ; F is fertilizer expenses ; D denotes the dummy variable for the conditions of water (D= 1 in cases of good water supply ; D = 0 in cases where water supply is inadequate). The results of the analysis of the intensive irrigated area are

Table 23. Production elasticities of nonglutinous rice (dry season, intensive irrigated area, 1985).

Constant term	Working hours	Fertilizers cost	Dummy	R^2
1.779	0.300 (2.752)	0.136 (2.624)	0.100 (1.873)	0.746

Note : The model is as follows :

$$\log\left(\frac{Y}{T}\right) = \alpha + \beta \log\left(\frac{L}{T}\right) + \gamma \log\left(\frac{F}{T}\right) + \sigma D$$

where Y is yield, T acreage of paddy cultivation, L working hours, F fertilizers cost and D dummy variable. Under good conditions of utilization of irrigation water $D=1$, and $D=0$ under bad conditions. Figures in parenthesis show t-values.

Table 24. Diffusion of direct sowing and its background in nonglutinous rice production (intensive irrigated area, 1985).

	Number of farm households (number)		Total acreage of cultivation (rai)		Acreage of cultivation (rai) per farm household		Acreage of cultivation (rai) per regular farm worker	
Season	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry
Transplanting	7 (63.6)	3 (21.4)	38 (40.0)	23.25 (11.4)	5.43	7.75	1.60	2.45
Direct sowing	4 (36.4)	11 (78.6)	57 (60.0)	180.75 (88.6)	14.25	16.43	4.38	5.42
Total	11 (100.0)	14 (100.0)	95 (100.0)	204 (100.0)	–	–	–	–

Note : Figures in parenthesis show percentages.

shown in Table 23.

10 out of 15 households answered that water supply was insufficient in the dry season (Table 18). The calculation of the production function also made it clear that the parametor of dummy variable was significant, and that the conditions of water use had a great influence on the improvement of rice yield per rai. It is advisable that water supply and utilization should be improved, not only in the rain-fed area and the extensive irrigated area but also in the intensive irrigated area as well.

10. The introduction of direct sowing and its economic effects

(1) The introduction of direct sowing

At the time of our survey, direct sowing had been widely introduced in the intensive irrigated area. In the extensive irrigated area only 1 household out of 15 was direct sowing. Direct sowing was not used at all in the rain-fed area. Direct sowing had also not been introduced in any of the three areas for growing glutinous rice. Therefore, our research concerning direct sowing was concentrated solely on non-

Table 25. Economic analysis of direct sowing in non glutinous rice production (intensive irrigated area, 1985).

		per rai							
		Yield (kg)		Working hours (hour)		Cash expenditures (bath)		Production cost (baht)	
Season		Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry
Transplanting		417	596	152.5	169.6	384.2	349.8	1,051	1,092
Conditions of utilization of irrigation water	Bad	333	296	157.8	249.2	406.2	353.3	1,097	1,444
	Good	480	742	148.6	129.9	367.7	348.0	1,018	916
Direct sowing		428	403	99.9	77.9	265.6	307.1	703	648
Conditions of utilization of irrigation water	Bad	410	385	137.9	81.1	346.3	309.4	950	664
	Good	434	455	87.3	69.3	238.7	301.2	621	604

Note : Production cost is calculated, on the assumption that the labor cost is 35 baht for 8 hours.

glutinous rice production in the intensive irrigated area.

As Table 24 shows, 4 out of 11 households in the intensive irrigated area directly sow rice in the rainy season compared to 11 households out of 14 in the dry season. One can deduce that in the rainy season rice transplanting (63.6 %) is used more than direct sowing (36.4 %). In comparison, during the dry season direct sowing (78.6 %) is more widely used than transplanting (21.4 %). However, when the total acreage under cultivation is compared, direct sowing is employed on a larger scale than transplanting in both the rainy season (60.0 % of the acreage) and the dry season (88.6 % of the acreage).

The total acreage cultivated by households that sow directly is 2.0 to 2.6 times larger than that of households that still use transplanting methods. The average acreage cultivated by regular farm worker that use direct sowing is 2.2 to 2.7 times larger than the average acreage cultivated by ragular farm worker who transplants. The above analysis shows that direct sowing had been introduced in order to save labor time during the busy farming season.

(2) Labor and production costs saved by direct sowing

Economically speaking, direct sowing saves labor and production cost. In Table 25 we compare production factors involved and the overall production of the two sowing methods. We have especially focused upon labor and production cost necessary for either direct or transplant sowing, and the rice yield per rai. As the rice yield, labor hours, cash expenditures and production cost greatly depend on the availability of irrigation water, Table 25 accounts for this variation by classifying fields accoring to the water availability.

As Table 25 clearly shows there is no significant difference in yield between methods that sow directly or transplant in the rainy season. It is unlikely that rice yield per rai will decrease if direct sowing is to be adopted by households which still use transplant sowing. In the dry season households which have adopted transplant

Table 26. Working hours per rai by process of non-glutinous rice production (rainy season, intensive irrigated area, 1985).

	Transplanting (hour)	Direct sowing (hour)
Nursery bed preparation	2.8	0.0
Plowing, puddling and basal dressing	3.6	2.6
Transplanting or direct sowing	64.6	5.3
Re-transplanting or direct re-sowing	5.3	2.6
Weeding	3.2	2.1
Water management	16.5	14.8
Spraying chemical	3.0	0.1
Top dressing	2.4	1.9
Harvesting	42.5	63.3
Threshing and winnowing	7.5	6.0
Storage	0.7	0 . 5
Selling	0.4	0.7
Total	152.5	99.9

Note : Figures in the table are taken from 7 transplanting farm households and 4 direct sowing farm households.

Table 27. Working hours per rai by process of non-glutinous rice production (dry season, intensive irrigated area, 1985).

	Transplanting (hour)	Direct sowing (hour)
Nursery bed preparation	2.1	0.0
Plowing, puddling and basal dressing	4.9	3.7
Transplanting or direct sowing	30.8	4.6
Re-transplanting or direct re-sowing	8.2	1.6
Weeding	0.2	0.8
Water management	61.7	10.1
Spraying chemical	**1.1**	1.7
Top dressing	4.0	2.0
Harvesting	54.8	49.8
Threshing and winnowing	1.2	2.5
Storage	0.1	0.3
Selling	0.5	0.8
Total	169.6	77.9

Note : Figures in the table are taken from 3 transplanting farm households and 11 direct sowing farm households.

sowing and have a sufficient supply of water produce by far the largest amount of rice. Consequently, the average rice yield per rai for households which use transplanting methods is higher than households which use direct sowing method. In cases where water supply is insufficient, direct sowing households produce more rice than transplant sowing households. It seems that direct sowing is a better method than transplant sowing when irrigation water is not regularly available.

The labor hours invested by rice planting households during cultivation are 150 to 170 hours per rai for transplant sowing, with 80 to 100 hours per rai for direct sowing

Table 28. Cash expenditures per rai by process of non-glutinous rice production (rainy season intensive irrigated area, 1985).

	Transplanting (baht)	Direct sowing (baht)
Nursery bed preparation	39.9	0.0
Plowing, puddling and basal dressing	44.7	45.9
Transplanting or direct sowing	79.9	3.9
Re-trasplanting or direct re-sowing	0.0	3.9
Weeding	7.3	5.0
Water management	27.3	8.0
Spraying chemical	13.1	0.8
Top dressing	60.9	46.3
Harvesting	46.6	108.1
Threshing and winnowing	30.5	25.4
Storage	15.7	6.5
Selling	18.3	11.8
Total	384.2	265.6

Note : Figures in the table are taken from 7 transplanting farm households and 4 direct sowing farm households.

Table 29. Cash expenditures per rai by process of non glutinous rice production (dry season intensive irrigated area, 1985).

	Transplanting (baht)	Direct sowing (baht)
Nursery bed preparation	5.4	0.0
Plowing, puddling and basal dressing	10.8	43.6
Transplanting or direct sowing	30.9	3.6
Re-transplanting or direct re-sowing	14.8	0.0
Weeding	7.9	5.3
Water management	10.7	13.5
Spraying chemical	27.7	9.9
Top dressing	93.7	83.9
Harvesting	65.9	106.2
Threshing and winnowing	45.2	23.8
Storage	10.0	3.8
Selling	26.8	13.5
Total	349.8	307.1

Note : Figures in the table are taken from 3 transplanting farm households and 11 direct sowing farm households.

households. During the dry season especially, direct sowing takes only 46 % of the labor time used by transplant sowing household.

Table 26 and 27 show in what processes farm labor is saved by the introduction of direct sowing. One obvious process is that the time required for planting has been considerably shortened. Moreover, during the dry season, water management time has been shortened.

Cash expenditures greatly differ according to the sowing method used. The cost

involved in direct sowing is much smaller than transplant sowing. The reason is that in transplant sowing it is necessary to hire laborers to finish the work on time, which adds greatly to expenses. This is obvious from Table 28 and 29, which compare the cash expenditures per rai in relation to the sequence of non-glutinous rice production during the rainy season (Table 28) and the dry season (Table 29).

In direct sowing cash expenditures and labor invested are lower than in transplant sowing. Consequently, the overall costs are lower if rice is directly sowed rather than transplanted.

It must be noted, however, that the figures used in Table 25 do not represent the exact production costs. The depreciation of capital goods was not included to these data. Despite these adjustments, the major economic effects of direct sowing are reflected clearly.

As shown in Table 25, the production cost per rai was 1,050 to 1,100 baht in case of transplant sowing, and 650 to 700 baht for direct sowing. The average cost of rice production per rai in North-East Thailnad was 780 baht in the rainy season, and 955 baht during the dry. The costs needed for rice production in the villages surveyed were smaller than the national average when direct sowing was used. However, costs were above average in cases where transplant sowing was used. The production costs per kg were obtained by dividing the production costs by the rice yield. The costs involved for rice production using transplant sowing per kg were 2.52 baht for the rainy season and 1.83 baht for the dry. In cases where direct sowing was used, production costs per kg were 1.64 baht in the rainy season and 1.61 baht during the dry. Just for interest, the average production costs per kg for the North-East Region were 3.82 baht in the rainy season and 2.27 baht during the dry.

Once again, the figures given do not represent the actual production costs because of insufficient date. However, from the data available it is clearly evident that direct sowing does save production costs. In the future rice prices are unlikely to increase, and as rice planting machines are still beyond the means of most farmers, direct sowing will play a great role in reducing production costs.

11. Rice variety, mixed crops and the rice cultivation calendar

Before the 1960's almost all the local variety of rice in Thailand were photosensitive. Attempts were made to cross these varieties with IR-8 which appeared in the later 1960's. Since 1969, a good quality variety with strong resistance to day light and disease has been brought into the market under the RD brand mark.

In the early stages, RD-1, RD-2 and RD-3 varieties were widely used. Today, as shown in Table 30, the RD-23 non-glutinous rice variety is grown during the rainy season; the RD-21 and RD-23 non-glutinous rice variety are used during the dry season, and the RD-6 and RD-8 glutinous rice variety are grown during the rainy season. Very few households grow the local Sanpatong and Lungtong variety. The spread of the RD variety has led to an increase in the demand for fertilizer. As shown in Table 19, fertilizer is a key factor for the improvement of productivity.

Due to the recent increase in the world rice production the portion of Thai rice being exported has been consistently decreasing. This tendency has urged Thai farmers to cultivate other crops instead of just rice. However, all of the three areas surveyed still used their paddy fields solely for rice growing. There were no sings of

Table 30. Number of farm households by variety of rice (1985).

		Variety	I	E	R
Rainy season	Non-glutinous	RD 21	2	0	0
		RD 23	7	0	0
		LT	0	3	1
	Glutinous	RD 6	0	9	7
		RD 8	9	7	3
		ST	1	0	2
Dry season	Non-glutinous	RD 3	0	1	
		RD 13	0	2	
		RD 21	4	2	
		RD 23	8	5	
		LT	0	1	

Note :1) LT, ST denote Lungtong and Sanpatong respectively.
2) I.E.R. symbols have the same meaning as in Table 1.

crop diversification. The crops that were grown other than rice (as shown in Table 31 and 32), were not cultivated in the paddy fields but either on upland fields, vegetable gardens or orchards.

In 1985, 6 crops other than rice were grown in the intensive irrigated area, 9 crops in the extensive irrigated area, and 8 crops in the rain-fed area. The most popular crops grown were Chinese cabbage, chili and Chinese mustard in the intensive irrigated area, longbeans, cucumbers and bananas in the extensive irrigated area, and cassava, bananas and soybeans in the rain-fed area. The average acreage allocated for cultivation per household for these diverse crops in 1985, was 0.54 rai in the intensive irrigated area, 2.01 rai in the extensive irrigated area, and 6.38 rai in the rain-fed area.

Table 33 shows the rice cultivation calendar for 1985, while Table 34 displays the production schedule for crops other than rice for the same year. During the rainy season, rice production usually begins in August for the rain-fed area but in June for the two irrigated areas. The rainy season harvest ends in January with the threshing and winnowing. The dry season rice is planted and reaped between February and June for the two irrigated areas.

Cassava is grown annnually. It is planted in October and harvested the next September/October. Soybeans are seeded in January and harvested in April.

Longbeans can be grown 3 times a year; cucumber about six, and Chinese cabbage around 4 times a year. Chili is seeded only once a year because of its numerous harvests per year.

Interestingly, some of the households in the rain-fed area use irrigation water for their vegetable gardens, although they don't use irrigation water to cultivate rice.

Irrigation water is not used just for cultivation but also for other everyday uses i. e. washing dishes and clothes, as drinking water for domestic animals, and for vegetable growing. This leads to an increase in household incomes and in the standard of everyday life.

Table 31. Diversification of production (1984)

I			E			R		
Crops	Number of farm house-holds	Acreage per farm house-hold (rai)	Crops	Number of farm house-holds	Acreage per farm house-hold (rai)	Crops	Number of farm house-holds	Acreage per farm house-hold (rai)
Squash	2	0.40	Cassava	3	1.40	Cassava	5	3.60
Banana	2	0.23	Tomato	2	0.04	Sugarcane	1	0.50
Chili	2	0.13	Sugarcane	1	0.70	Peanut	1	0.30
Soybean	1	0.20	Longbean	1	0.05	Corn	1	0.50
Mango	1	0.20	Peanut	1	0.20			
Lemon	1	0.20	Cucumber	1	0.01			
Tomato	1	0.08						
Eggplant	1	0.05						
Papaya	1	0.03						
Celery	1	0.03						
Total	13	1.55	Total	9	2.40	Total	8	4.90

Note : I.E.R. symbols have the same meaning as in Table 1

Table 32. Diversification of production (1985).

I			E			R		
Crops	Number of farm house-holds	Acreage per farm house-hold (rai)	Crops	Number of farm house-holds	Acreage per farm house-hold (rai)	Crops	Number of farm house-holds	Acreage per farm house-hold (rai)
Chinese cabbage	5	0.28	Longbean	10	0.77	Cassava	5	2.53
Chili	4	0.08	Cucumber	4	0.17	Banana	5	0.41
Chinese mustard	3	0.12	Banana	4	0.15	Soybean	3	1.07
Onion	2	0.02	Cassava	2	0.43	Sugarcane	2	2.00
Eggplant	1	0.03	Chili	1	0.03	Cucumber	2	0.08
Mint	1	0.01	Pepper	1	0.03	Cowpea	1	0.02
			Peanut	1	0.03	Pepper	1	0.07
			Mango	1	0.07	Corn	1	0.20
			Soybean	1	0.33			
Total	16	0.54	Total	25	2.01	Total	20	6.38

Note : I.E.R. symbols have the same meaning as in Table 1.

DISCUSSION

We have assumed from the outset that poverty in developing countries can be partly solved by an increase in the income of individual farm households. This can be done by increasing and stabilizing rice yield, and/or by introducing new kind of crops. These two possibilities can be realized if a consistent supply of irrigation water is

Table 33. Cultivation calendar of rice (intensive irrigated area, extensive irrigated area and rain-fed area, 1985).

		J	F	M	A	M	J	J	A	S	O	N	D
Irrigated paddy field	Rainy season	TW					NP	PP BD	T	WM	W TD	WM	H
	Dry season		NP PP	BD T	WM	TD	H TW						
Rain-fed paddy field	Rainy season	TW							NP PP	BD T	WM	TD	H

Note : NP = Nursery Bed Preparation, PP = Plowing and Puddling, T = Transplanting, W = Weeding, WM = Water Management, H = Harvesting, TW = Threshing and Winnowing, S = Selling, BD = Basal Dressing, TD = Top Dressing, SD = Seeding, PL = Plowing, WI = Watering

Table 34. Cultivation calendar of crops other than rice (intensive irrigated area, extensive irrigated area and rain-fed area, 1985).

	J	F	M	A	M	J	J	A	S	O	N	D
Cassava									H S	PL T	w	w
Soybean	PL SD	W WI	W TD	H S								
Longbean		PL SD W	WI	H S	PL SD W	WI	H S		PL SD W	WI	H S	
Cucumber	W H S	PL SD WI	w H s	PL SD WI	w H s	PL SD WI	w H s	PL SD WI	w H s	PL SD WI	w H s	PL SD WI
Chinese cabbage	PL SD BD	w WI H	PL SD BD	w WI H				PL SD BD	w WI H	PL SD BD	w WI H	
Chili		PL SD WI	WI	TD W WI	TD WI	H WI	H WI	H WI	H WI			

Note : Refer Table 33.

made available, An increase in income will allow farm households to invest more capital in cultivation (i. e. pesticides and fertilizers) and to give their children a higher education, which would directly help the overall development of the regions further. We tested our hypothesis by conducting a survey comprising of 75 farm households in an intensive irrigated area, an extensive irrigated area, and a rain-fed area in North-East Thailand. From the data collected we analyzed the changes in agricultural management brought about by irrigation development.

1. Summary

(1) In the two irrigated areas, the majority of households were engaged in full-time farming rather than part-time farming. In contrast, in the rain-fed area most households were engaged in part-time farming.

(2) In the two irrigated areas even small-scale farm households could afford to give their children education above the compulsory level. However, in the rain-fed area, only large-scale households could give their children the same standard of education.

(3) There was hardly any difference between the three areas in size of the paddy fields held per household. However, upland field was cultivated more widely in the rain-fed area than the two irrigated areas. Consequently, the total cultivation acreage per household was the largest in the rain-fed area (25.0 rai), the second largest is the extensive irrigated area (20.6 rai), and the smallest is the intensive irrigated area (16.0 rai).

(4) The selling and buying of land seldom takes place. The price of a 1 rai paddy field was 20,000 baht in the intensive irrigated area, and 14,000 baht in the rain-fed area.

(5) The number of tenant farmers in the survey was small. Land was usually leased between relatives, although a few lands were leased. Rent was usually a fixed sum of money which was paid in cash.

(6) In the two irrigated areas tractors were used to cultivate farm land which reduce the time needed for plowing. In the rain-fed area buffaloes were still mostly used.

(7) The value of barns, agricultural implements, cattle, poultry and fish in the intensive irrigated area is three times larger than those of rain-fed area.

(8) The acreage alloted for rice cultivation per household was 26.3 rai in the intensive irrigated area, 24.5 rai in the extensive irrigated area, and 17.2 rai in the rain-fed area. The cultivation area in the rain-fed area was the smallest because double cropping is impossible. Low productivity and a limited amount of land suitable for cultivation are the main factors which block an increase in income in the rain-fed area.

(9) The land use rate of paddy field was 186.5 % in the intensive irrigated area, 156 % in the extensive irrigated area, and 100 % in the rain-fed area.

(10) The glutinous rice yield per rai during the rainy season was 501.9 kg in the intensive irrigated area, 403.8 kg in the extensive irrigated area, and 280 kg in the rain-fed area. The non-glutinous rice yield per rai during the rainy season was 473.3 kg in the intensive irrigated area, 429.6 kg in the extensive irrigated area, and 289.0 kg in the rain-fed area. The national rice yield per rai during the rainy season was 263 kg.

(11) The variation coefficient for the yearly rice yield per rai for individual farm households taken on a scale or 100, was 23 % in the intensive irrigated area, 31.9 % in the extensive irrigated area, and 46.4 % in the rain-fed area.

(12) The agricultural income per household was 27,771 baht in the intensive irrigated area, 35,896 baht in the extensive irrigated area, and 12,798 baht in the rain-fed area. The average income for a farm household, the sum of agricultural and part-time *jobs* income was 35,644 baht in the intensive irrigated area, 38,467 baht

in the extensive irrigated area, and 21,976 baht in the rain-fed area. The national average income for a farm household was ***34,537*** baht, 24,675 baht in the North-East Region. The average farm household incomes in the two irrigated areas were higher than the national average. The agricultural development had occurred in the area was due to the investment taken in various irrigation schemes.

(13) The agricultural extension service found in the two irrigated area was the main agent in introducing new farming techniques. In the rain-fed area many households still obtain their information primarily from their neighbors.

(14) Irrigation water was not used just for rice cultivation but also as drinking water for domestic animals, vegegable growing, and for washing dishes and clothes. The supply of irrigation water has helped to increase the total income of the area and to improve sanitary conditions.

(15) Direct sowing had been introduced in the intensive irrigated area, which has helped to cut production cost for rice growing.

The above conclusions reveal that irrigation development initially increased then stabilized rice yield per rai. This effect raised the income above the national average, which supports our initial hypothesis. However, there are many obstacles which nagate the benefits irrigation development brings.

2. **Obstales of agricultural development**

(1) Greater irrigation investment has taken place in the intensive irrigated area than in the extensive irrigated area. In the intensive irrigated area, land consolidation has led to the realization on individual drainage. However, as shown in Table 19, the supply of irrigation water is insufficient in boht the dry and rainy seasons. This common complaint was most frequent in the intensive irrigated area. Also, Table 12 showed that non-glutinous rice yield per rai during the dry season was the largest in the extensive irrigated area. Considering the results of our data and the financial conditions of the Thai Government, extensive irrigation is more favourable than intensive irrigation because it obtains greater effects with less investment and in a shorter period of time.

(2) On the other hand, as a solution to the problem of rice overproduction, the diverse cultivation of paddy fields is necessary. This is impossible in extensive irrigated paddy fields where irrigation is plot-to-plot. Considering the need for diversification, extensive irrigation is not suitable.

(3) Membership in the Agricultural Cooperative Society was moderate. Local farmers still depend on merchants for the purhase of agricultural materials, the sale of agricultural products and obtaining loans. The Agricultural Cooperative Society needs to function more efficiently if local farmers are to receive some advantages.

(4) The widespread use of a variety of rice congenial to heavy dressing has made fertilizers a key factor in improving productivity. However, the relative price of fertilizers to rice is increasing. Consequently, local farmers have difficulty in affording fertilizers.

(5) Direct sowing has spread in the intensive irrigated area. This has saved the farmers a lot of labor time. However, the time saved by farmers is spent in

part-time jobs. Therefore, although sowing time has been saved, new opportunities for employment in the agricultural sector have not materialized.

(6) The lack of labor power during rice planting has been solved by the introduction of direct sowing. However, Table 26 and 27 show that there is a great lack of labor power during harvest time which restrains further enlargement of the cultivation acreage.

(7) An international surplus in agricultural products has led to a decrease in rice and upland field crops exports from Thailand. This has discouraged land utilization and crop diversification in Thailand. The depressed global economy for agricultural products and its internal repercussions has forestalled agricultural development in Thailand.

In this paper we have confined our study only to the agricultural sector. However, in order to solve poverty completely in developing countries it is also necessary to do research on the international trade of agricultural products.

ACKNOWLEDGEMENTS

This work was supported by a Grant-in-Aid for Overseas Scientific Survey (No. 59042007 and 60041051) from the Ministry of Education, Science and Culture of Japan. The authors wish to thank the National Research Council of Thailand for their permission to conduct research in Thailand. We are deeply indebted to the Royal Irrigation Department, the Ministry of Agriculture and Co-operatives of Thailand for their kind help with the field survey.

REFERENCES

Hasegawa, Y. 1983 *Tokoku Tai no Genjo to Shorai (Present Situation and Future in North-East Thailand).* Kokusai Noringyo Kyoryoku Kyokai, Tokyo (in Japanese)

Ishii, Y. ed. 1975 *Taikoku — Hitotsu no Inasaku Skakai — (Thailand : A Rice Growing Society).* Sobunsha, Tokyo (in Japanese)

Kathpalia, G. N. 1983 System operation in Nong Wai Pioneer Agriculture Project. *In* "Nong Wai Irrigation Management Seminar Report", ed. by Asian Development Bank, Royal Irrigation Department, Khon Kaen (Thailand)

Kitahara, A. 1985 *Kaikatsu to Nogyo — Tonan Ajia no Skikonskugika — (Development and Agriculture : Capitalization in Southeast Asia).* Sekaishisosha, Kyoto (in Japanese)

Kuriya, T. 1982 *Taikoku Keizai Gaikyo (General Condition of Thai Economy).* Japanese Chamber of Commerce and Industry in Bangkok, Bangkok (in Japanese)

Ministry of Agriculture and Co-operatives 1983 *Agricultural Statistics of Thailand,* Bangkok

Miyazaki, T. 1985 Oyako nogyo kyodo Keiei to sogo fujoteki kariwake kosaku ni kansuru hikaku kenkyu (Comparative study on the sharecropping and the partnership between father and son-in law in northeast Thailand). *Noringyo Mondai Kenkyu (J. Rural Problem), 21* : 72-79 (in Japanese)

Mizuno, K. 1982 *Tai Noson no Skakai Soskiki (Social Structure of Rural Communities in Thailand).* Sobunsha, Tokyo (in Japanese)

Schultz, T. W. 1979 *The Economics of Being Poor.* Nobel Foundation, Stockholm

Suwit, P. 1977 Thailand. *In* "Farm Water Management for Rice Cultivation", ed. by Asian Productivity Organization, Nordica International Limited, Hong Kong, pp. 316-325

Takaya, K. 1982 *Nettai Deluta no Nogyo Hatten — Menam • Deluta no Kenkyu — (Agricultural Development in the Tropical Delta : Studies on the Menam Delta).* Sobunsha, Tokyo (in Japanese)

Tsuchiya, K. 1976 *Productivity and Technological Progress* in *Japanese Agriculture.* University of

Tokyo Press, Tokyo
Tsuchiya, K. 1981 *Sekai no Shokuryo• Nihon no Nogyo (World Food and Japanese Agriculture).* Norin Tokei Kyokai, Tokyo (in Japanese)